The Journal of
NERVOUS and
MENTAL DISEASE

VOL. 126, NO. 4
APRIL, 1958
SERIAL NO. 908

THE DEVELOPMENT OF CONCEPTS RELATING TO THE ELECTRICAL ACTIVITY OF THE BRAIN

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The electrical activity of the brain may conveniently be classed under three headings: (1) potential shifts evoked by nerve impulses initiated by changes in the organism's internal or external environment; (2) the steady potential difference that is always present between the cortical surface and the white matter below it; and (3) the oscillating potential of the brain commonly called the electroencephalogram. All of these electrical events are interdependent. The changes of potential in category (1) are of the order of a few millivolts in reptiles and lower animals, of microvolts in monkey and man. Those in category (2) are of the order of several millivolts, those in (3) rarely more than 200 microvolts in normal man when recorded through the skull and scalp. It was in the search for potentials of the first category that the electroencephalogram was discovered in the nineteenth century.

GROWTH OF THE CONCEPT OF NERVE ELECTRICITY

The observations of Galvani (49a) that so startled the scientific world in 1791 included among others the finding (which he did not understand at the time) that when a nerve or muscle is injured, a current flows from the outer uninjured surface to the cut one. Galvani's preparation was a pair of frog's legs, intact up to the knees with the sciatic nerves laid bare above, and retaining their connection to a truncated piece of the vertebral column. The complexities of this preparation and Galvani's lack of our present day knowledge of electricity masked the true character of the phenomena he demonstrated.

It was the Italian scientist Matteucci (83), professor of physics at Pisa, who in 1838 established the "muscle current" (as he called it), and Du Bois-Reymond (41), professor of physiology at Berlin, who confirmed it and in addition demonstrated the "nerve current." There was still some uncertainty among physiologists as to how much of this potential difference was intrinsic to nervous tissue (*i.e.* a resting potential) and how much an artifact due to injury (*i.e.* a current of injury). Hermann (60), Du Bois-Reymond's pupil, named the latter the demarcation potential and took the extreme view that all the electricity in nerve came from this source. His teacher held out for the existence of intrinsic animal electricity and went on to discover that the steady potential difference between cut surface and the undamaged exterior of a nerve trunk changed if he stimulated the nerve. He called this the "negative variation." This was the first demonstration of the action potential of nerve and it was this finding that led directly to the discovery of the electro-

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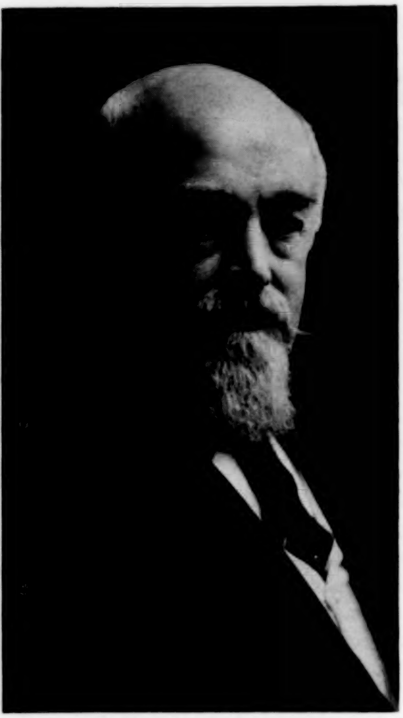

FIG. 1. Richard Caton, the discoverer of the electroencephalogram. (From a studio portrait, the generous gift to the author from Miss Anne Caton.)

encephalogram, a discovery made independently at times 15 years apart in two widely separated countries.

DISCOVERY OF THE ELECTROENCEPHALOGRAM

The first discovery was made by Richard Caton (26) working at Liverpool University where he was later to have a chair in Physiology created for him (Fig. 1). He set out to see whether the negative variation in demarcation potential that Du Bois-Reymond had found in nerve could be demonstrated in brain on stimulation of any of its sense receptors. In other words, Caton was looking for the potential swing that is classified as type (1) in the categories listed at the beginning of this essay. However, he not only found what he was looking for, but he also had the acumen to note (and not discard as later workers did) an unexpected finding. This was that when both his electrodes were on uncut cortex (thereby excluding the demarcation currents) there were incessant fluctuations of potential even when he eliminated all experimental stimulation of the animal. He named these the "electric currents of the brain" and reported them to the British Medical Association in 1875, and to the International Medical Congress in Washington in 1887, after paying a visit to the City Hospital in Boston. He visited Russia in 1897. In spite of his discovery appearing in the journals of three countries: England (26), the United States (27) and Russia (28), it remained comparatively unnoticed.

Fifteen years later Adolf Beck, a young instructor in physiology at the University of Jagiellianski in Krakau planned his work for an inaugural thesis with exactly the same concepts in mind that had activated Caton's researches, namely a search for signs of action potentials in the brain when impulses initiated in sense organs passed through it. Beck was as successful as Caton, though ignorant of his work, and published his thesis in full in the Polish language (5) and in shorter form in German (in 1890) (6).

ELECTRICAL LOCALIZATION OF BRAIN REGIONS

In the latter part of the nineteenth century when these pioneers were publishing their novel findings, neurophysiologists were engrossed with the controversial issue as to whether the various faculties, physical and mental, had specific locations in the brain, and it was therefore the localizing potentialities of the evoked changes in the electrical activity of the brain that were most eagerly adopted, its fluctuating baseline being ignored.

Views of cerebral localization varied from adherence to Gall and Spurzheim (49) who favored specific locations for mental faculties, through those who sought centers for sensory and motor functions (for example, Gotch and Horsley (57)) to those, like Flourens (46), who took a global view of the three main divisions of the brain. The new electrophysiologic technique gave experimenters another tool, and even the first to use it, Caton, succeeded in demonstrating responses to photic stimulation in both rabbits and monkeys, though he failed with sounds. Beck, who specifically named his thesis "The determination of localization of brain and spinal cord function by means of electrical phenomena" was equally successful with photic stimuli. An independent physiologist, Fleischl von Marxow (44, 45) in Vienna, also working in ignorance of Caton's discoveries, localized the visual responses in animals and attempted olfactory stimulation.

As the twentieth century opened, the ruling concept of the electrical activity of the brain was still related to its response mechanisms, but in studying these, workers in many laboratories—in Poland (7, 33) and in Russia (34, 68, 89, 90)—were observing and learning about the fluctuating baseline potentials of the brain "at rest." To their aid had come the great invention of the vacuum tube and its use in electronic amplifiers, so that Caton's "feeble currents" could now be magnified and studied in detail. The work of these experimenters received recognition in their own countries though some (98) thought the potential changes recorded were all artifacts due to muscle movements. It was only when a German worker, after repeating and confirming Caton's observations on animals showed that what was true for monkey was true for man that the rest of the scientific world began to take notice (Fig. 2).

FIG. 2. Hans Berger, the first to record the electroencephalogram of man and to apply the technique to clinical problems. (From: Kolle, K. Grosse Nervenartzte. Stuttgart, Thieme. 1956)

THE ELECTROENCEPHALOGRAM IN MAN

Hans Berger, a psychiatrist in a hospital in Jena, who later reported having made unpublished studies on the electrical activity of the brain in animals since 1902, while working in secretive seclusion in his laboratory extended his investigation to man in 1924. One of his first subjects was his young son, from whom he was able to record a fine 10 per second rhythm. Prawdicz-Neminski (89, 90), in Russia, had differentiated in dogs the two types of rhythm now known as α and β and Berger found their counterparts in man (8). He applied the same tests that Caton had used for establishing the biologic origin of these rhythms, namely hypoxia and anesthesia, and acknowledged his indebtedness to his predecessor. The outstanding contribution of Berger is not only that he demonstrated for the first time the electroencephalogram of man, but that he established its abnormality in epilepsy. His discoveries are directly responsible for the existence of the hundreds of clinical electroencephalographic laboratories that are now to be found all over the world. Not until 1929 did Berger share his findings with the scientific world. In that year and during several to follow he published a long series of papers that are the classics of electroencephalography. His last paper was published in 1938, and in 1941 he committed suicide.

Berger's concept of the electroencephalogram seems to have been a global one. In many of his first experiments he used two very large electrodes, one on the forehead, one on the occiput (though in some he used needles inserted in the scalp). As a result he was plagued by muscle artifacts and although he detected an abnormality during epileptic seizures he missed the spike potentials of cerebral origin that accompany them. His single fronto-occipital placement of electrodes hid from him the localizing potentialities of the electroencephalogram.

The global concept of the brain's oscillating potentials finally gave way before Adrian and Yamigawa's demonstration (by phase reversal) that the α-rhythm in normal man is localizable to the occipital regions (3), (a finding that Berger was unwilling to accept as correct). Then a whole new field of clinical application was opened up by Grey Walter's discoveries in 1936 (102) that it was not necessary to open the skull to detect from the tissue surrounding a neoplasm abnormally slow potential swings (which he named δ-waves), that the tumor tissue itself is electrically silent, and that Adrian's technique of phase reversal can be used to locate cerebral tumors through the unopened skull.

The year before, another outstanding contribution had been made to clinical electroencephalography. This was the discovery by Gibbs, Davis and Lennox (52) of the three per second wave-and-spike discharge in petit mal epilepsy. This finding and that of Grey Walter's of δ-waves associated with brain tumors remain to this day the two major diagnostic aids of the clinical electroencephalographer.

THE SEARCH FOR THE UNDERLYING PHYSIOLOGY

Meanwhile investigators were puzzling over the nature of the oscillating waves. In the first three decades of this century nerve physiology was dominated by the "all or nothing" law and by the discoveries that were being made in axonology. Progress in this field was accelerated by the development of vacuum tube amplifiers and by the application of the cathode ray oscilloscope to the detection of biologic potentials. It naturally followed that attempts to explain the comparatively slow potential changes of the brain should first be made in terms of envelopes of axon spikes. Axon spikes in the periphery have a duration of less than a millisecond, and very many of them, slightly asynchronous in their discharge, would be needed to give the envelope of one α-wave. Later knowledge showed some spikes (from the discharge of cell bodies) to be of only slightly longer duration (2 to 3 milliseconds), and soon physiologists began to look for electrical events within the brain that had a slower time-course. The structures that suggested themselves were the dendrites. Among the first to recognize this possibility were Gerard, Bremer and Bishop and later they were to be joined by Adrian. But it is only in recent years when recording from microelectrodes in the brain became an established technique that this concept has come to the fore in a more detailed form.

It will be noticed that any concept that considered the axon spike as the building block of the cortical wave implied neuronal activity in the form of a discharge. All the empirical observations of the α-wave in man pointed to its being a phenomenon of the brain at rest (though not asleep), and for many years the major application of the recording of brain potentials was channeled in this direction. In the clinical laboratories the patients were examined in quiet conditions and told to make their "minds a blank." Many painstaking and somewhat unrewarding studies were undertaken in attempts to correlate these recordings of the "engine when idling" with psychologic states and psychiatric conditions, for Berger, himself a psychiatrist, had hoped the brain's rhythms would relate to mental processes (9).

To many, however, electrical activity

meant neuronal activity of some kind and not a mere state of rest. Early in the development of this branch of electrophysiology, Bremer suggested that the oscillating potentials were the sign of "tonus" in the cortex (23), indicators of fluctuation in excitability rather than of discharge. The concept of electroencephalographic potentials being concomitants of the excitability changes of cortical neurones is basic to today's thinking. In the intervening years, however, the possibility that the α-rhythm might be related to transmission of impulses in the brain has not been entirely abandoned. In the 1940s the ingenious suggestion was made, first by Marshall and Talbot (82), and later independently by Craik (32), by Walter (101) and by Pitts and McCulloch (88) that the α-rhythm might act as a scanning mechanism setting the level of excitability of the visual projection areas for incoming stimuli, and hence it would play a role in the perception of form. Attractive as this hypothesis was, it did not stand up to the experimental testing of MacKay (77) or of Walsh (100).

Throughout most of this period the parameter of the α-rhythm that claimed the most interest was its frequency. In line with the hint derived from Caton that anoxia had a depressing effect on the electrical currents of the brain, numerous studies of cerebral metabolism were initiated in the many countries where interest had now been aroused. The indubitable relationship of any form of neuronal activity, electrical or otherwise, to the metabolism of the neurones concerned made this a fruitful field, and at this time Gibbs (51) proposed a system of chemical oscillators as the underlying mechanism of the EEG. The work of Lennox and the Gibbses (71) on the oxygen and carbon dioxide content of the blood, that of Davis and Wallace (37) on overbreathing and that of Hoagland (62) on the effect of anoxia and of insulin on the frequency parameter are outstanding among the early work in this area.

Emphasis on the frequency characteristics of the electroencephalogram created a demand for an instrumental method for its determination and this resulted in the design by several centers of instruments for automatic frequency analysis. Two different designs, that of Gibbs and Grass (53), and that of Walter (103) were applied to the quantification of frequency changes resulting from alterations in cerebral metabolism (54, 14), a problem for which they were the suitable tool since no transient or paroxysmal potentials were present to confuse the analysis. Among the newer techniques developed in recent years are the frequency analyser of Storm van Leeuwen and co-workers (95), the toposcopic analysis designed by Walter and Shipton (104), and the application of autocorrelation to the study of the periodic component of the EEG (19).

The susceptibility of the brain's electrical activity to changes in its metabolism is marked in the second category of potentials listed at the beginning of this essay, namely the transcortical potential difference. The detecting devices of the earliest workers (such as Caton, who used nonpolarizable electrodes) allowed them to see swings in this potential, but the advent of the electronic amplifier brought with it circuits with resistance-capacitance coupling. Such circuits, almost ubiquitous in all commercially distributed equipment for routine clinical electroencephalography prevent slow fluctuations of steady potential from being seen by the electroencephalogram. Directly coupled amplifiers have been available, but only in comparatively recent years has the technical difficulty of drift been overcome. This disadvantage, together with the problems introduced by the necessity for using nonpolarizable electrodes held back the investigation of this aspect of the brain's electrical activity for many years. The recent design of chopper circuits has, however, now made the study of steady potentials a practical laboratory technique that is proving exceedingly fruitful.

Prominent among the groups studying these steady potentials are the workers at Washington University in St. Louis. In their opening investigations (on man and animals) Goldring and O'Leary (55) concluded that the potential measured in this way is the algebraic resultant of two components of opposite sign tending to balance in a manner consistent with cerebral homeostasis. Certain chemical agents applied to the cortical surface enhance the component contributing to surface positivity (*e.g.* veratrine or malononitrile), and others augment the one responsible for surface negativity (*e.g.* strychnine). These slow potentials are influential on the brain's response to peripheral stimuli and the effect of disturbances of this homeostasis is reflected, not only in distortions of the positive or negative phases of primary cortical responses to such stimuli, but in the prolongation of cortical disturbance resulting from a single stimulus. Later work by the same team has taken this technique into the clinical field, where one of its applications is in the detection of changes due to vascular occlusion. Another clinical application has been opened by Cohn (30) with his discovery of the marked shift of this potential during the three per second wave-and-spike paroxysms of the petit mal attack. This finding has been confirmed by Bates (4) and by Walter (105). Apart from the import such findings have for the elucidation of brain dysfunction, it would seem that no hypothesis that attempts to relate memory traces or the interaction of sensory modalities within the brain to neuronal events should ignore these long-persisting electrical changes.

In the last decade a marked change in the standard clinical test has become general. The hypothesis that abnormalities in the brain's structure would be revealed best by studying its electrical activity when "at rest" has been largely replaced by a search for anomalies of brain function when its neurones are "at work." In the majority of clinical laboratories today the response characteristics of the electroencephalogram form an important part of the routine examination. Until after the war the only form of activation generally used was that of overbreathing, a test directly related to the concept of cerebral metabolism being the basic formulator of the brain's rhythms. In **1948** the Walters and the Gastauts published a joint paper (**107**) on the evocation of seizure discharges in certain epileptics by photic stimulation. It had been known to clinicians that some patients reported that their seizures were provoked by incidentally encountered flickering lights but the technique now became a laboratory procedure. The number of epileptic patients who are photo-sensitive is relatively small (perhaps not more than 6 per cent) but by lowering the convulsive threshold by careful systemic administration of metrazol a differentiation can be made between the normal reaction of photic driving and the abnormal one of paroxysmal discharge (92). Metrazol alone had been used to activate seizure patterns in the EEG since **1938** when Cook and Walter (**31**) and Strauss and Landis (**96**) published their initial findings.

That the brain potentials of the normal animal or man can be driven to the frequency of an intermittent light shone in the eyes is among the earliest of observations in this field. In Washington in **1887** Caton (**27**) reported that he "tried the effect of alternate intervals of light and darkness" and that in those experiments in which he succeeded "the relation between the intervals of light and darkness and the movement of the galvanometer needle was quite beyond question." In more modern times the following of the flash frequency by the brain rhythm was beautifully illustrated by Adrian and Matthews (**2**) and later demonstrated quantitatively by automatic analysis by Walter and associates (**106**). The latter technique revealed a persistence of the α-rhythm coincident with a resonance to the flicker rate that made α-driving a misnomer.

Photic stimulation is not the only form of activation used by the modern electroencephalographer. Another, which may at first glance again seem a misnomer is the induction of sleep. One of the early findings of Berger (10) was that the EEG changed as his subject fell asleep though from his description it would appear that he was observing drowsiness rather than deep slumber. It was in 1935 that descriptions of the EEG in normal man in sleep came from Loomis, Harvey and Hobart (75) and in 1937 from investigators in many countries: from Klaue (69) and from Drohocki (40) in Germany, from Blake and Gerard (13) in the United States, and from Marinesco, Sager and Kreindler (81) in Roumania. The electrical activity of normal sleeping man consists of slow potential swings and the Davises and their co-workers (35), realizing this, in 1939 used direct coupled amplifiers to record them. Although a focus of slow waves at the vertex was found by the Davises, it was only later (15) that emphasis was laid on the fact that not only frequency but location of maximal activity changed in sleep. In the latter state maximal potential gradients are recorded in the precentral regions in place of the occipital foci of the α-rhythm in the awake subject, and this shift of focus gives the objective demarcation between drowsiness and sleep.

In the course of these investigations of the sleep state considerable information was gathered on the effects on the EEG of soporific drugs and this was added to the accumulating material on the action of anesthetics and of anticonvulsant drugs (70, 20, 99). The application of "activation" by sleep to clinical electroencephalography derives from the discovery by Fuster and the Gibbses (50) that spike potentials from the temporal cortex occur more frequently in patients with temporal lobe epilepsy when they are asleep than when they are awake. A further use of the sleeping state in clinical electroencephalography is based on the Davises' finding in 1939 (36) that stimulation from any sensory modality, but most strikingly that from sound, evokes a characteristic potential change in the precentral region on the human head. This phenomenon, named by the Davises the "K-complex" has been used with success by Fischgold (43) in the elucidation of comatose states.

Noticeable in this discussion of the sleep state is the omission of any reference so far to Bremer's classic work. The omission has been purposeful, for an attempt will now be made to lead up to a current hypothesis of the basic mechanisms responsible for EEG potentials. This hypothesis will lean heavily on the ideas and findings of others who will be named, but they should not be held responsible for the speculative synthesis that will be attempted. In any case, the statement of the hypothesis that follows should be regarded as fundamentally statistical in nature, the parameters of which can only be described in terms of probabilities.

Running like a golden thread through the fabric of electroencephalographic knowledge is a characteristic of the electrical activity of cortical cells that provides the unifying factor for the many diverse phenomena that have been empirically established in normal man and in the patient with brain disease.

The clue was noticed by the first man to discover the electrical activity of the brain and has been observed by every worker in electroencephalography since then. The key finding is that changes in states of consciousness are accompanied by alterations in cortical potentials. Caton's observations on the effect of anesthesia (26), Berger's confirmation of them and his notes on sleep (10), his discovery that alpha activity waned when the eyes were opened, Adrian's demonstration (2) that this phenomenon accompanied consciously directed vision rather than mere eye-opening—all of these logic explanation. The first major lead came from Bremer whose classic finding is the cornerstone of modern electroencephalographic theory.

In 1935 Bremer (22) observed that a cat whose neuraxis was transected at the intercollicular level, *i.e.* one whose cerebrum was isolated from its mesencephalic brain stem, remained in an apparently sleeping state that was accompanied by slow waves in the electroencephalogram. Bremer named this preparation the "*cerveau isolé*" and explained the chronic sleep state as being due to a de-afferentation of the brain, retention of the first two pairs of cranial nerves (the optic and olfactory) being insufficient to keep the animal awake. Bremer went on to show that if the transection were made lower down (at a level of the first cervical vertebra) the animal retained its sleep-waking cycle with the appropriate electroencephalographic concomitants. This preparation in which the whole contents of the cranium retained their interconnections though losing their spinal inflow, Bremer named the "*encéphale isolé*." His demonstrations made clear the importance of the integrity of the mesencephalic brain stem for the state of vigilance, an observation which tallied with and became explanatory for the symptoms of brain stem disease familiar to the clinician.

Involvement of subcortical neuronal influences in problems of sleep and wakefulness had been emphasized by previous workers, though attention in these studies had been given to more rostral structures in the diencephalic brain stem. For example, Hess (61) had defined in cats a region lateral to the massa intermedia, extending caudally to the habenular-interpeduncular tract and rostrally to the mammillo-thalamic bundle, stimulation of which induced a sleep-like state. In the years immediately following Bremer's publication the first experimental evidence for implication of the hypothalamus came from Ranson and Magoun (91), and 6 years later Murphy and Gellhorn (86) showed that electrical stimulation of the hypothalamus altered the electroencephalographic pattern. The later work of Ingram *et al.* (63) added further to our knowledge of the relationships between hypothalamic and cortical activity.

That electroencephalographic potentials recorded from the cortical surface were influenced by diencephalic activity was definitively established by the work of Morison and Dempsey (84), published in a series of papers in the early forties. Their work stemmed from that of Forbes and his associates demonstrating that even in deep anesthesia sensory impulses reach the cortex (39). At that time (1936) this seemed a paradoxical finding for it was generally believed that arrival of sensory impulses at the cortex was associated with "awareness" of them. Forbes and Morison (47) went on to show that in addition to the impulses that passed through the thalamus to the cortex from the periphery in both the vigilant and the anesthetic state, there were others traveling by a different route. Thus it was established that the cortex had supply lines from the periphery that bypassed the classical lemniscal tracts with their nuclei in the thalamic nuclei specific to the sensory modality involved. Moreover, Forbes's group showed that impulses traveling up this nonspecific route affected the cortex diffusely and not merely in circumscribed areas devoted to the modality of the sense organ originally stimulated. The existence of multiple afferent systems to the cortex supplies the element of redundancy of information so necessary for the maintenance of stability in a self-organizing system such as the brain.

This was the first hint of the existence of a neuronal system that could influence the cortex in a wider and more general sense than had been previously demonstrated electrophysiologically. The first drive to follow up this lead was focussed on the diencephalic structures involved and received most concentrated study from Morison and Dempsey (84, 38). These workers were able to make clear distinctions between the dual ascending systems from the diencephalic level of the brain stem. In the classical system the responses evoked at the cortex were of short latency, and discretely and unilaterally located. In the nonspecific system the latency of response is markedly longer, bilaterally distributed and has the remarkable characteristic (peculiar to this system) that repetitive stimulation at a rate approximating to that of the brain's own rhythms evokes successive increase in amplitude of response over widespread areas of the cortex. Morison and Dempsey named this phenomenon the recruiting response.

The finding of a bilaterally distributed electrical event in the cortex resulting from stimulation of medial nonspecific nuclei in the thalamus was the basis for Jasper and Droogleever Fortuyn's (**67**) hypothesis to explain the bilaterally synchronous discharges of petit mal epilepsy familiar to all electroencephalographers. No hypothesis for their mechanism had been suggested until these workers (**67**) in **1947** recognized the importance of this diffuse thalamic projection system. Jasper and Marsan (**64, 65**) gave the system this name and went on to map its diencephalic nuclei and to investigate their influence on cortical potentials. Jasper's results led him to suggest a schema in which cell bodies in the intralaminar nuclei and the nucleus reticularis of the diencephalon might have direct projections to the cortex.

In **1949** a discovery was published that has been profoundly influential on the understanding of the electroencephalogram and has opened a line of investigation of the brain in terms of integration and behavior that was previously hidden. This was the demonstration by Moruzzi and Magoun (**85**) that electrical stimulation of the central core of the mesencephalic brain stem has an arousing reaction outlasting the stimulus (usually both behaviorally and electrophysiologic properties of the brain similar to the alerting evoked by peripheral stimulation. The anatomic connections and electrophysiologic properties of the brainstem had previously received extensive study from Magoun (**78**) for several years, and had resulted in the demonstration by him of caudally directed facilitatory and inhibitory influences (**80**). The new finding, of import for anyone interested in the brain and behavior, was of a cephalically directed control (**79**), not only of the electroencephalographic potentials, but of the state of vigilance of the animal.

The electroencephalographic change in the neocortex resulting from stimulation of this ascending activating system in the sleeping animal is a shift from slow waves of high voltage to fast activity of low voltage. This change is immediately reminiscent of the modification in the electroencephalogram that accompanies alert attention to visual stimuli ("α-blocking"), a phenomenon noted by Berger and studied more intensively by Adrian and Matthews (**2**) and by Jasper and Cruikshank (**66**) in their early work and by many others since then. The correlation of the shift to this fast type of activity with a change to behavioral alertness is indubitable. No hypotheses concerning "consciousness," "awareness," "attention," or sleep can ignore the impact of this finding.

That the pertinent pathways of this system lie in the mesial brainstem and are not dependent on integrity of the more laterally placed classical sensory tracts has been proven by the ablation and transection experiments of Lindsley and associates (**73, 74**). Evidence for this system receiving its sensory inflow through collaterals from the classical sensory paths has been provided by Starzl, Taylor and Magoun (**94**). Bremer's classic observation that his *cerveau isolé* preparation cannot be aroused from apparent sleep is now explicable on these grounds, rather than as the result of section of the specific sensory afferents. Bremer was however correct in using the term "deafferentation" because afferent impulses are necessary to excite this system if it is to keep the animal in a state of vigilance.

Once the impulses from the periphery have entered the reticular core they lose the information they carry as to sense modality through interaction on the same neurons and take on the function of activating the ascending system so that the cortex may be in an appropriate state of facilitation or inhibition for processing of the impulses received by the specific routes (for there is evidence also for an ascending inhibitory influence) (76, 16). It is the specific impulses travelling in their segregated pathways that convey the message as to which sense organ received the initial stimulus.

ATTEMPTS TO REACH A NEURONAL ANALYSIS

One further area of knowledge needs to be outlined before an attempt at synthesis can be made. This concerns the intimate electrophysiology of the neuronal elements in the cortex whose potentials are being discussed. In the recording of potentials from the unopened skull and scalp of man it is extremely unlikely that the electrodes pick up electrical activity of any neuronal units farther from them than those in the outer cortical mantle. As noted above the activity of these neurones is under control from lower centers but the extracellular current flows of the deeper units do not cause sufficiently steep voltage gradients on the scalp for surface electrodes to detect potential differences. Evidence for this statement comes from personal experience with implanted electrodes in patients with temporal lobe epilepsy (21). Such electrodes in the conscious patient may record seizure discharges of extremely high voltage (500 microvolts and more) in deep structures without any disturbance of the electroencephalogram recorded from the scalp (Fig. 3). This fact, the experience of all who have recorded in this way from epileptic patients, is a sober-

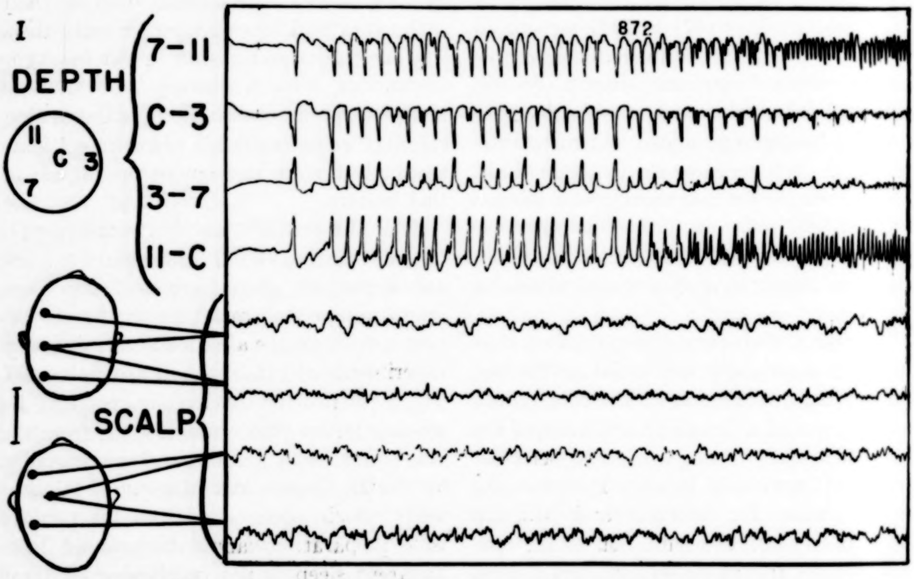

FIG. 3. Seizure discharge in the amygdaloid region of a patient with temporal lobe epilepsy. Note that the seizure discharge does not reach the scalp electrodes. The amygdaloid electrodes were implanted parallel to the interaural line. The numbers on the circle on the left indicate the spatial relationship of the amygdaloid recording points in the parasagittal plane. Interelectrode distance was 3 mm., the central point C being 3 mm. shorter than the others.

ing corrective for anyone in the habit of regarding a normal scalp recording as contraindicative of an epileptic condition. Another reason for doubting whether any but cortical potentials contribute to the electroencephalogram recorded from the scalp is the impedance of the brain tissue. This is greater than that of saline by a considerable factor and, as Freygang and Landau (**48**) have shown, white matter has an even higher impedance than grey. An added complexity is the recent demonstration by Brown (**24**) that intracerebral impedance levels are dynamic rather than static.

If the oscillating potentials recorded from the scalp originate in cortical neurones they must be derived from nerve cells whose component units are uniformly oriented, for were they randomly distributed their potential fields would tend to cancel each other. One of the outstanding contributions that the physiologist with his microelectrode has made in recent years is the demonstration that all parts of a neurone do not have the same electrical characteristics. Not only are the time characteristics of the spike discharge greatly different for the cell body, the axon and the dendrite respectively, but the recovery rates after a discharge are vastly different. This means that activity in any part of a cell or its processes sets up extracellular current flows between the rapidly repolarizing areas of membrane and the more slowly recovering parts. In order for these current flows to reach a density that can be recorded at the scalp they must be closely massed and flowing predominantly in the same direction. A field of current flow of density adequate to meet these requirements, from structures geometrically oriented so that the voltage gradients they present at the cortex are sufficiently steep, is found in the radially oriented apical shafts of the pyramidal cells reaching up and branching towards the cortical surface. Moreover, these long dendritic processes have electrical characteristics radically different from those of their cells and axons and thus with their extensive area of membrane constitute a powerful source of extracellular current flow.

It should be noted however that on anatomical grounds this is a vast oversimplification, for the cell structure and layering of the cortex, especially in regions other than the visual receiving area, is of a complexity that defies an analysis such as this which ignores other cellular components whose orientation is less conspicuous.

As mentioned above, the role of the apical dendrite as a significant structure in EEG potentials has been suggested by many neurophysiologists: Adrian, Bremer, Gerard, O'Leary, Eccles, Chang, Tasaki, and outstandingly by Bishop. It is to Bishop (**11**) that the electrophysiologist owes a great deal of his knowledge of these structures and the matrix of the hypotheses as to the role they play. In recent years the experimental findings of Grundfest (**58**) and Purpura have drawn added attention to transmission at synapses between axon endings and dendrites, and for the electroencephalographer knowledge of synaptic potentials is essential, for they have been postulated as the stuff of which cortical rhythms are made (for example, by Li and Jasper (**72**) and others cited above).

As Bishop and Clare (**12**) have demonstrated, normal activity in these dendrites appears to consist very largely of nonpropagated graded potentials spreading decrementally from the point at which the stimulus is received. These nonpropagated potentials are of long duration and are not all-or-nothing in character, but reflect the strength of the stimulus. They have no refractory period and can therefore sum with any consequent potentials that are set up before they die away. This discovery of graded responses in the central nervous system brought with it a flood of interpretations of brain mechanisms that had previously proved difficult to reconcile with the rigidity imposed by the all-or-nothing law of neuronal behavior. Conceptual models of activity similar to digital computers with either a "yes" or "no" action gave way to the greater flexibility of analog models in which varying degrees of stimulation evoked graded responses. The lack of a refractory period with the resultant effect that an incoming impulse could sum with the traces of a previous one gave a basis for the nonlinearity of response that is so typical of the biologic system.

No experience finds the organism in the same condition twice. Every event changes the organism in some way so that the relation of input to output is nonlinear. This fact lies at the basis of all learning, all conditioning, all habituation. Explanation of this in neuronal terms was elusive as long as the response mechanisms of the brain were conceived as analogous to those of peripheral nerve where the summation of new with past events was largely excluded by refractoriness.

It has been pointed out is a previous publication (17) that in the experimental animal dendrites can only with difficulty be made to give a spike discharge and this finding was cited in relation to the fact that one of the outstanding characteristics of the normal brain is that it does not give spikes in recordings from the convexity of the cortex. The spike of the epileptic discharge is not merely an excessive form of a normally occurring event, it is a new entity unknown to the normal brain.

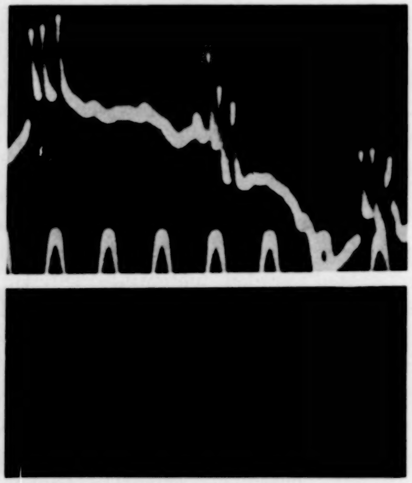

FIG. 4. *Above.* Cell discharges recorded from an electrode 1 mm. below the pial surface of the cat's visual cortex. Duration of each spike approximately 2 msec. *Below.* A spike recorded from an epileptic patient. Duration of spike approximately 15 msec.

In both photographs the time-line peaks occur at 10-msec. intervals. (Reproduced from reference #17)

The spikes from the epileptic cortex are of far longer duration than those of axon or cell-body discharge, being never less than 15 milliseconds and usually nearer 30 (Fig. 4). This is of the order of the spike potential of the dendrite when it can be induced to fire and the suggestion was therefore made (17) that the typical epileptic spike is an abnormal discharge of apical dendrites of pyramidal cells in some cases fired from the cortical surface—as for example by scar tissue, and in others by triggering from lower centers *via* the nonspecific afferents synapsing onto them in the higher levels of the cortex.

The firing of abnormal dendritic spikes from the surface can be mimicked in the experimental animal by stimulation of the cortical surface as was shown long ago by Adrian (1) and more recently by Bishop and Clare (12) and others (97). The surface negative spike evoked in this way has a duration of about 15 milliseconds and has been shown by the microelectrode recordings of Burns and Grafstein (25) to lose its negativity at a level 0.7 mm. below the pial surface in the cat's cortex. When excessive, the discharge may spread antidromically down the dendrites to their cell bodies and fire them. Since these cell bodies are the pyramidal cells that carry the efferent discharges from the cortex any mass firing of them spreading to the motor cortex could evoke violent muscular movements (or, in other words, the clinically observable epileptic fit).

What protects the normal brain from

this disaster? Why does not every discharge of the pyramidal cells resulting from impulses bombarding them from the specific afferents spread up the dendrites and fire them? In another place (18) the suggestion has been made that a feedback of an inhibitory nature plays on the cell body, through returning axon collaterals and small inhibitory interneurones, in such a way as to limit the degree of depolarization that it can develop. There is evidence now from intracellular microelectrode studies of Phillips (87) for the presence of small interneurones in the cortex whose function is solely inhibitory, *i.e.,* their action is to produce a postsynaptic hyperpolarization (and not the depolarization typical of the excitatory state). Such cells are analogous in their function to the inhibitory cells discovered by Renshaw (93) in the spinal cord whose hyperpolarizing characteristics have recently been studied by Eccles *et al.* (42). The existence of recurrent collaterals from the axons of pyramidal cells has been known ever since the beautiful drawings of Camillo Golgi (56) (Fig. 5).

The inhibitory influence reining in the over-action of cortical efferent discharge may be what saves the normal brain from the convulsive seizure. It is only one of a complex of integrating controls, for the brain stem in addition to its projection routes to the cortex receives a return inflow not only from the cortex but from the cerebellum. The brain stem also has a control system acting centrifugally on the sense receptors themselves. There is now evidence from the work of Hernandez Peón (59) that in the actively alert state accompanying conscious attention selective perception of certain stimuli may be mediated through inhibition of nonpertinent sensory inflow, the inhibitory influence being carried by the centrifugal fibers from the brain stem to the receptor organs.

The hypothetical synthesis now begins to take shape: In the resting but awake brain the typical α-rhythm is compounded of the massed synaptic potentials of the apical dendrites of pyramidal cells, synchronization resulting from the electrical field of maximal amplitude present in the total activity. In such a postulate the rhythm of this massed activity would be expected to be of lower frequency than that of the fluctuations of its individual units and to be influenced by the degree of depolarization they retain over and above their discharge threshold. The constant influx of stimuli from the external and internal environment of the organism reaches the pyramidal cells through the specific afferents (probably with an intercalated Golgi type-2 cell), and the resultant postsynaptic depolarization moves towards the cortical surface by electrotonic spread in the apical dendrites. The degree of depolarization of the dendritic tree (the substratum of the EEG) is controlled by the arrival *via* nonspecific afferents of facilitatory and inhibitory impulses from the brain stem modifying the level of excitability. This type of afferent plays onto the dendrites by axodendritic synapsis in the superficial layers of the cortex, adding algebraically to the summating level of polarization. At the same time any excessive development of discharge by the pyramidal cells is checked by the hyperpolarizing action of the small inhibitory cells activated by recurrent collaterals of these same pyramidal cells. The relative time courses of these three events with their different rates of recovery set the rhythm of the waking brain.

In summary then, variations from this homeostatic condition may be conjectured to occur as follows:

1. Sleep or coma: Remove the activating influence of the ascending reticular system and the α-rhythm is lost; the slow waves of sleep or coma come in its place with their behavioral correlates.

2. Vigilance: Activate the ascending reticular system beyond the homeostatic level of the resting brain and the α is replaced

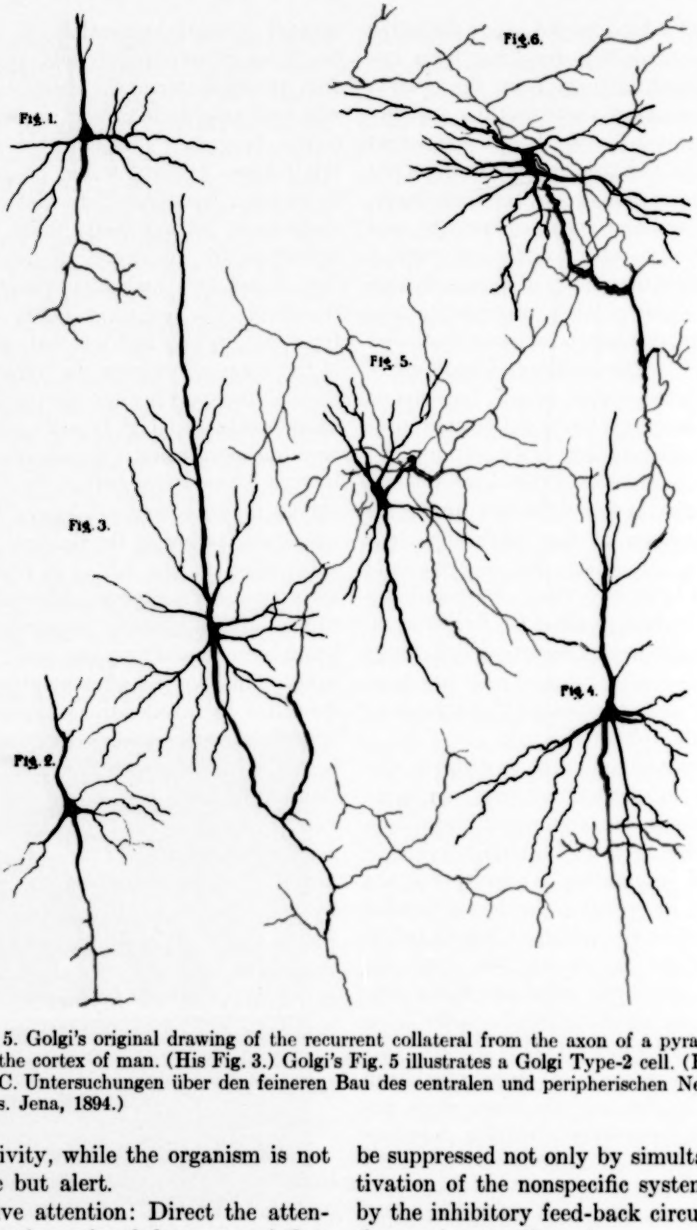

FIG. 5. Golgi's original drawing of the recurrent collateral from the axon of a pyramidal cell in the cortex of man. (His Fig. 3.) Golgi's Fig. 5 illustrates a Golgi Type-2 cell. (From: Golgi, C. Untersuchungen über den feineren Bau des centralen und peripherischen Nervensystems. Jena, 1894.)

by fast activity, while the organism is not only awake but alert.

3. Selective attention: Direct the attention to a fraction only of the sensory inflow and both facilitatory and inhibitory influences come into play in order to highlight the part and mask the surround.

4. Efferent output: Activate the pyramidal cells through their specific afferents to a state of discharge and the α-rhythm will be suppressed not only by simultaneous activation of the nonspecific system but also by the inhibitory feed-back circuit through the recurrent collaterals.

5. Photic driving: Repetitive stimulation in a uniform manner of a given afferent system may cause a persisting facilitation of intercellular transmission extending beyond the pathways used by stray stimuli, the projection system for this being in part the

specific one (as in photic activation of seizures). On a short time-base this could be the mechanism underlying photic driving.

6. Conditioned reflexes: On a longer time-base a somewhat similar facilitation of transmission resulting from repetitive coincidence of two different modalities of stimulus (a degree of coincidence that must exceed chance) may be the substratum of the EEG correlates of some types of conditioned reflex.

7. Barbiturate anesthesia: Barbiturate, after a preliminary short-lasting stage in which it affects the cortex and excites the patient, acts on the core of the lower brain stem blocking its ascending control with resultant impairment of consciousness, loss of α-rhythm and release of spindle bursts from the nonspecific thalamic system. In the patient with temporal lobe epilepsy and involvement of the amygdaloid-temporal complex, this loss of restraint under sedative doses of barbiturate releases dendritic spiking at the cortex.

8. Cortical spiking in grand mal epilepsy: Disturb the inhibitory feed-back circuit of axon collaterals and the dendrites will spike and, if spread reaches the motor systems, convulsions will follow. Unlike petit mal discharges the mechanism for these involves primarily the cortex and the specific projection nuclei.

9. Petit mal absences: Activity of the reticular system has been proved to block the recruiting action of the nonspecific thalamic system. Withdrawal of this blocking effect during loss of conciousness in petit mal attacks releases abnormal recruiting activity from these centers, driving the association cortex to a bilaterally synchronous discharge. The self-sustaining character of these discharges suggests the interaction of two mutually controlling variables.

10. Brain tumors: Replace the apical dendrites by superficially growing tumor tissue and the α-rhythm will be abolished. According to Ward (**108**), tumors below the cortex have, superimposed on their δ-waves, the faster potentials of the dendrites that lie between them and the surface. Tumors of the cerebrum, not themselves invading the dendritic layer, but interrupting the afferent paths interfere with all their (testable) response mechanisms.

11. Destructive lesions of the mesencephalic brain stem abolish all α-rhythm and produce a comatose state.

The above synthesis, stated here in oversimplified terms, necessarily lacks precision at this stage. One can only plead (in Adrian's words) that "It is difficult to resist speculating about the integrative processes of the brain because the whole of human achievement depends on them." In any case the role of the dendrite as outlined here is highly conjectural and should be regarded as an assumption open to serious question. Only experiment can decide the issue.

The development from the concept of the electroencephalogram as primarily an aid in assessing the normality of the resting "inactive" brain to a dynamic formulation of it as an indicator of the brain in action has, by emphasis on function rather than on structure, suggested a wider application of the EEG to the study of behavior. It should be no surprise if, in addition to the newer applications of the EEG in neurosurgery, it is in the investigation of the physiology of learning, of behavior and of conditioned reflexes that the major contributions of the next few years will lie.

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[2] This is not intended as an encyclopedic bibliography. In most cases an author's first publication of a discovery is cited rather than his mature assessment of it. In this way it is hoped that some continuity of the historical unfolding of knowledge may have been preserved.

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THE PSYCHOLOGIC IMPORTANCE OF THE UTERUS AND ITS FUNCTIONS

SOME PSYCHOANALYTIC IMPLICATIONS OF HYSTERECTOMY

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The recent investigation of 23 patients who had undergone hysterectomy for benign and malignant disease of the female reproductive tract was undertaken as part of a larger study of the psychologic effect of removal of various organs in patients with neoplastic diseases (1, 7, 11). In the report on hysterectomy (7), the authors focused attention on the adaptation of women to this operation, with emphasis on the emotional factors which contributed to delay in seeking treatment, preoperative and postoperative psychologic disturbances, and excessively prolonged convalescence. In addition, a number of observations of psychoanalytic importance have emerged from this research which are reported and discussed herein. These observations are concerned with a woman's attitudes and emotional reactions when she is faced with the imminent loss of the uterus, and the psychologic consequences after surgical removal of the uterus has taken place.

TECHNIQUE AND RATIONALE

The subjects of this investigation were randomly selected from premenopausal women who were scheduled to undergo hysterectomy at Memorial Center. Fourteen patients had benign disease while nine had malignant disease of the uterus. None had had previous psychiatric examination or referrals. All patients received intensive, focused interviews preoperatively. They were seen during their postoperative convalescence in the hospital, and were followed for 6 to 12 months after surgery. In preoperative interviews attention was focused on the patient's conscious attitudes and emotional responses in anticipation of the surgical procedure in general, and the loss of the uterus in particular. Postoperatively the domestic, occupational, social and sexual adjustments were specifically explored, but in all interviews the patients were encouraged to ventilate freely and all associational material, including dreams and fantasies were encouraged and discussed.

Based on the general psychologic concepts derived from previous studies dealing with the psychologic impact of cancer and cancer surgery, certain assumptions were made about the patients who are seen in this acute stressful situation. We expect that under acute stress adaptive techniques of an individual become exaggerated and more obvious. Furthermore, it has been found that the individual's defenses may prove ineffectual in dealing with this overwhelming stress (11). A person's previously unformulated attitudes and conflicts about work, sex, disease, death and relatedness to others often become conceptualized and expressed (4, 8, 10). Patients who had heretofore never consciously formulated their attitudes towards a particular organ of their body became aware that they harbored within themselves certain definite beliefs about their anatomy, their physiology, and the value of a particular organ in their total life adjustment. After an organ had been surgically resected it was frequently found that substitute defensive and adaptive patterns were established by the patient. From the behavior patterns developed in reaction to surgical removal of a specific

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organ, the specific role that the organ previously played in the psychologic economy can be inferred.

REPRODUCTIVE FUNCTION OF THE UTERUS

The major concern expressed in preoperative interviews by these premenopausal women who undergo hysterectomy involves the anticipated loss of childbearing ability. It is easy to demonstrate that most women have a wish to bear and raise children. Furthermore, psychoanalysis of women who have no conscious wish for children often reveals pregnancy wishes which are disguised or repressed because of fears or inhibitions. Deutsch (6) and Benedek (3) present evidence supporting the thesis that there is a maternal instinct in every woman. The findings of our study cannot contribute to the clarification of the problem of whether maternal wishes are instinctual or learned drives. A high degree of concern and regret has emerged, however, in younger women who were either childless or had not completed their family when faced with hysterectomy. Most of the women expressed spontaneous regret over the loss of their ability to ever again become pregnant. They gave a variety of reasons for wanting children and for regretting the loss of childbearing ability. Some wanted children because of personal sense of gratification and fulfilment derived from bearing and raising a child. Some wanted a child so that they could have an object to love. Others appeared to desire children more to please others than to fulfil themselves. A 26-year-old divorced woman who had a child by her first husband stated, "I want to remarry someday and I want to have a child for my second husband. He might want to have a son of his own and if he didn't he might resent my child by my first husband." An unmarried woman reported, "There are certain things expected of a woman by a man. One of them is having a child for him." This particular woman who wanted to have a child "for him" was perpetuating her characteristic adaptive pattern in life which involved the belief that she must "give to others" in order to be accepted. A 23-year-old divorced woman with one child stated, "After my daughter was born I couldn't conceive. I felt incomplete and empty. Women are put on earth to have children. I've been trying to get pregnant for five years. I thought it was my fault." This woman found it necessary to deny a feeling of loss and rationalized that she welcomed the operation. She said, "I blamed it all on myself when I couldn't get pregnant, but now I'm glad that the operation will prove that it's not my fault."

Some patients denied apprehension over the loss of their reproductive organs and some consciously seemed to welcome the operation, but this was often a denial of intolerable feelings of impending loss. A 35-year old unmarried woman was originally admitted to the hospital with a diagnosis of fibroid of the uterus and was informed that she was to have a hysterectomy. She evidenced no conscious regret over the loss of the uterus and indicated that she was only interested in having her disease cured. It was discovered at operation that a myomectomy rather than a hysterectomy was needed and she was informed postoperatively that her uterus was intact. She responded with considerable elation and indicated that she had been trying to conceal her deeply felt regret over her expected sterilization.

Two patients appeared to welcome the operation because it eliminated the possibility of undesired pregnancy and would relieve them of the burden of previously troublesome contraceptive techniques. These were women whose families were as large as they felt they wanted and for whom further pregnancy would have been a social or economic burden.

It is clear, then, that the ability to have children and the bearing and raising of children serves a variety of needs and functions in the adaptation of different women. For some it is consciously valued as a source of pleasure and fulfilment, for others it is verbalized as a necessary concession to men, an act of giving which satisfies the husband's paternal needs, or his "conceit," or both. For some women, even though they desired no more children, the knowledge that they were able to bear children gave them the feeling of being complete and feminine, and the loss of childbearing ability was viewed as rendering a woman something less than a complete female. Furthermore, the two patients who stated that they welcomed the hysterectomy for contraceptive reasons expressed regret over the loss of the uterus for one or another of the specific feminine functions which they realistically or irrationally attributed to the possession of this organ. We emphasize that the regret expressed for any specific reason may have covered regret for other reasons either unstated or denied.

MENSTRUAL FUNCTION OF THE UTERUS

Menstruation is a uniquely feminine experience and its imminent termination, as an obvious consequence of hysterectomy, was given considerable attention by the women studied. A variety of real and fictional values were attached to the menstrual experience, and its expected termination elicited several different reactions in the women concerned. Three women, for whom menstruation had been a painful, or temporarily disabling experience, expressed a sense of relief preoperatively in anticipation of the cessation of their menstrual function. For the majority of the women in our study, however, the menstrual periods were looked upon as a necessary and valuable function whose termination was viewed with regret. This was true not only for those for whom menstrual periods had been a painless, matter-of-fact experience, but a number for whom the periods had been a source of discomfort and occasional disability still viewed their menstrual period as a valued and important experience, which they would have preferred to retain in spite of the monthly discomfort.

One function attributed to menstruation is excretion. One woman reported, "I used to have pains at times, but I feel my periods are a good thing—they clean me out and I'm sorry they're going to stop." Another woman stated, "After my periods are over I feel very good, like I have been cleaned out." Drastic consequences were expected by one highly superstitious woman when she anticipated termination of her menstrual function. "Menstruation is good for the body. That's why the good Lord made it. It's the waste of the body and if you don't menstruate, you don't get rid of the waste. It will affect your nerves. It's got to go somewhere."

Another value attributed to the menstrual periods by several women involved the concept of "the rhythm of life, the organized pattern." These women viewed the menstrual cycle as a kind of physiologic metronome which regulates their life's activities and lends a predictability to their daily living. "I used to believe that your strength was drawn from you when you had a menstruation. After my periods I felt fine. I felt I could tear the place apart. I felt I had triple strength. As a matter of fact, I used to plan my wash and my ironing with my menstrual period in mind. I also planned trips, visiting and social life for the few days after my flow."

In the psychologic literature the negative attitudes towards menstruation are usually mentioned and the positive value of it as conceived by many women is rarely emphasized or frequently omitted entirely. The fact emerges from this study, however, that despite the frequent negative attitudes expressed by many women towards the symptoms which accompany their menstrual periods, the majority of women feel primarily positive feelings towards the menstrual function as a whole and deplore the loss of this valued activity. Menstruation is valued as a cleaning or excretory function, as a part of the "rhythm of life," as a source of reborn strength and vitality, and as a periodic occurrence deemed necessary for the maintenance of health and well-being. To the extent that the uterus is seen as an excretory organ, it is likely that certain preexisting attitudes towards the rectum and bladder, the actual excretory organs of the body, may be transferred to the uterus and these may comprise, in part, some of the irrational and unrealistic attitudes towards uterine function. To the extent that the uterus is seen as a clock-like timing device, it serves as the control or regulator of other bodily functions. The loss of this regulating device is unconsciously viewed as threatening to disrupt other bodily functions which are dependent upon the menstrual cycle for regulation, as well as disrupting preexisting patterns of adaptation, patterns of work, sexual and social activities which have been organized within the periodicity of the menstrual month.

SEXUAL FUNCTION OF THE UTERUS

The concept of the uterus as being in some way important in maintaining sexual functioning was verbalized by 15 women. Preoperatively some feared that the hysterectomy would cause a lessening of their sexual desire and a decrease or disappearance of their ability to respond sexually. Some feared that there would be a loss of sexual attractiveness with resultant loss of their husband's interest, which, in an extreme instance, included a fear of infidelity and desertion by a disinterested husband.

Patients questioned their female friends and relatives about sexual changes to be expected from hysterectomy. One patient reported, "Some women I asked said that sex is better than ever after the operation. There are no pregnancy worries. As a matter of fact, that's the predominant opinion of the women I've spoken to. You can really let go for the first time. Some others have said that you have ailments after the operation and that makes sex worse. I hope it doesn't make my varicose veins any worse." Although this woman had been apparently reassured by most of her friends that there would be no adverse sexual changes and that there might be improvement in sex life following hysterectomy, she was more preoccupied with the viewpoint about postoperative ailments which worsen sex. Her deep underlying anxieties were not relieved by the superficial reassurances of her contemporaries. She remained highly preoccupied with her varicose veins and repeatedly talked about the anticipated enlargement of these veins and the detrimental effect on her appearance.

Three women who had been sexually responsive preoperatively expressed the belief that "the female organs" were the actual origin of their sexual desire and were necessary for orgasm. "They say when they take out a woman's organs she doesn't feel anything sexual any more." There were four married women in this study for whom sex desire and responsiveness was threatening and tabooed. They described a total absence of interest or desire for sex in the preoperative inquiry. These women stated that sex had always been a duty or obligation to their husbands and never a source of personal pleasure. "The whole thing was unpleasant to me, I didn't crave it. It's a wife's duty to give in to her husband and I usually give in to him because I love him." As will be discussed below, one of these women, though not consciously aware of sexual desire, nevertheless, in several ways showed concern over the possible postoperative loss of sexual sensations. Two women expressed the belief that sexual desire and responsiveness was largely psychologically determined, and they did not anticipate a lessening of desire or responsiveness from hysterectomy. "If a woman is warm before, she'll be warm after."

One 40-year-old patient clearly illustrated her concept of the uterus as her "sex organ." Her husband had been partially disabled by a chronic neurologic disease and had made very infrequent sexual overtures to her for several years. Her chief complaint to the gynecologist was a feeling of swelling, distention and pressure in her midabdominal region. She consciously visualized her uterus as having the characteristics of an "internal penis." She felt that the intermittent distention of her abdomen was caused by her uterus becoming swollen and erect due to sexual desire. Because of her husband's indifference to her sexual needs and her reluctance to seek an alternate sexual outlet, she felt that her uterus remained engorged and turgid, allegedly returning to normal only after her infrequent sexual intercourse with her husband. She stated, "If I were a man I'd be walking around with a big penis all the time."

The sexual adaptation of the women in this study can be divided into three groups corresponding to the attitudes mentioned above: (1) Seven patients who were sexually responsive before hysterectomy and who feared that they might lose their sexual desire. (2) Ten patients were unresponsive sexually in their preoperative adaptation and, therefore, consciously anticipated no changes. (3) Six patients who were responsive but did not consciously associate sexual feelings with possession of the uterus. In all three groups some anxieties were expressed concerning the woman's ability to participate in sexual relations, even where the woman had seen her role as a completely passive one. Three patients feared that they would have to reject their husbands because of their own pain. Others expressed the belief that their husbands might not receive complete gratification from them because they now had defective sexual equipment. Others felt that the hysterectomy would render them unsatisfactory sexual partners to their mates. "I never told my husband exactly the type of operation I had. I was told he might not notice the difference anyhow. But if he knew exactly what they took out, I think it would upset him a great deal. I'm afraid he wouldn't be interested in me any more." One patient stated with intense anxiety, "Married relations are all we've got. That's the main thing that keeps us together. If I'm no good for that he'll leave me."

For some patients sex was not only the fulfilment of biologic drive, but also one avenue for effecting human contact and relatedness. For these women hysterectomy, with anticipated impairment of sexual functioning, threatened serious disturbances in relatedness to spouse and other men, including fears of rejection and isolation.

Since the above data was derived from preoperative interviews, it is necessary to compare this to the actual state of sexual adjustment in these same women postoperatively. Five women who were sexually active and responsive before their illness reported no change at all from the preoperative sexual patterns. The remainder described some change in their sexual behavior and reactions. Pain and numerous somatic symptoms which persisted for months postoperatively interfered with the effective sexual functioning of several women. In addition to these secondary effects of the operation, six women described a change in sexual pattern which they attributed directly to their hysterectomy. One stated she had become reluctant to participate in sex because she believed herself to be "raw" inside. "I'm afraid of my insides. Afraid of my husband's coming near me. I told him to take it easy and be careful. I don't know what to expect but I expected the worst." A 38-year-old woman who had been very active sexually before her operation stated, "I get sex ideas but I get all upset. I'm afraid I'll do something wrong and end up sick again." This woman had previously stated that she believed her uterine disease was caused originally by excessive sexual activity, and her guilt and fear are reflected in her irrational postoperative cautiousness. A woman's guilt over her sexuality and her fear of returning to an active life following hysterectomy is often reinforced by the equally irrational guilt in her husband. Three women reported that their husbands believed that they were now fragile and vulnerable inside, and, consequently, the husband was afraid to make his usual sexual overtures.

A 23-year-old woman who had a total hysterectomy for a carcinoma of the cervix reported that she no longer had her previously intense sexual desires. She was convinced that her pelvic organs were the source of her sexual feelings and that she had lost an important part of herself which was necessary for sexual sensations and functioning. So important was sex in her preoperative adjustment that she felt now that life was barely worth living.

A 40-year-old woman reported that her desire for men was entirely unchanged. However, she described a "lump" in her vagina which made intercourse exquisitely painful and virtually impossible. A careful gynecologic examination revealed no such lump and no physical impairment which could conceivably impair sexual functioning. Her dyspareunia and vaginissmus persisted and it became apparent that she was convinced that the operation had not changed her sexual desire but that it had so damaged her sexual apparatus that sexual relationships were no longer possible.

A 40-year-old woman reported that sex had now become disagreeable to her because her husband no longer used contraceptives. "It's not painful, but now I get the dirty deal," said this compulsively clean and fastidious person. Her husband's semen, which she regarded as "the dirty deal" was abhorrent to her and made the entire sex act, in the absence of contraception, a negative experience for her.

It is apparent that while the sex life of many of our patients was very decidedly affected by the hysterectomy, the manifestations of change were in no way uniform. Five patients had no decrease in their sexual desires or effective sexual functioning. A number of patients believed themselves to be raw, tender and vulnerable inside, although they could see that their external incision had completely healed. One felt she had a lump in her vagina, while another reported that her vagina had become stiff, enlarged, and old and, therefore, was not able to function properly.

Since the patients in this study underwent complete hysterectomy involving removal of the fallopian tubes and ovaries as well as the uterus, the problem of the effect of oophorectomy on sexual activity must be considered. Benedek (3) found "that sexual excitability, desire for sexual gratification, and the capacity to achieve it do not cease immediately with the menopause; women who are not frigid before may keep their orgastic potency for a long time. There are also some women whose orgastic capabilities, as if released from fear, definitely increase for a period during the climacteria." This author was referring to the natural menopause which is often less precipitous than the artificial menopause induced by surgery. Ford and Beach (9) have reviewed the literature on the effect of ovariectomy on sexual behavior. All the reports that they cite indicate that "ovariectomized women are capable of experiencing normal sexual desire and of participating successfully in coital relations." Our findings, including five cases where sexual desire and response were not apparently altered by the operation, confirm and broaden the conclusions that ovariectomy and the advent of the surgical menopause in mature females does not in itself necessarily cause a decrease in sexual desire or capabilities. Disturbances of sexual functioning, when they do occur, are not uniform and are related to irrational fears and beliefs concerning the loss of the valued organ and to the psychologic effects of surgery in the genital area.

THE UTERUS AS A SOURCE OF STRENGTH, HEALTH AND GENERAL EFFECTIVENESS

The fourth major concern of women who were about to undergo hysterectomy related to their ability to carry out their every day functions, duties and obligations. A number of housewives expressed deep concern lest they be unable to carry out their necessary rest and recuperative period that surgery would ordinarily require, and was frequently expressed as a possibility that they might be forever rendered helpless and ineffectual in carrying out their essential obligations. So crucial was the performance of domestic duties that six women had delayed surgery and neglected serious gynecologic symptoms until they were unable to carry on their duties at home. Their inability to do their housework was the principle conscious motive for seeking medical care and the only justification for absenting themselves from domestic duties. A 40-year-old housewife with advanced carcinoma of the cervix attempted to deny the seriousness of her disease and stated, "I really fell well now. I feel I could scrub floors." This woman attempted to convince herself that just as long as she was able to carry out her household duties there was really no impairment of her health.

Twelve women expected that their operation would in some way have a deleterious effect on their strength. One stated, "I wonder if I'll be able to work after this operation. Will I be as strong as I was before? I feel that I'm losing something and that losing it will take away some of my strength. You're supposed to have all your organs. If you lose one you're just not as good as before." This patient expressed the belief that strength and health were related to intactness, and that any loss in the totality of the body make-up would take away some of her strength. For those women whose adaptive patterns included a compulsion to serve and care for others, any operation or illness which is incapacitating was a particular threat. One stated, "I'll never get any rest at home if I go straight back there. All the relatives live around where we are and I know they'll be coming in and out to visit. I won't be able to lie in my bed knowing that there's no food made and so much work to do. I just could never keep off my feet if that much work was to be done and I was home, no matter how badly I felt."

For some women the hysterectomy is seen as a greater threat to their strength and vitality than any other type of subtractive surgery. One patient stated, "I know this operation definitely affects your strength. It may sound silly but I believe your strength comes from your womanly organs. Some women have told me that they would never allow this operation to be done on them no matter what they had." Two patients stated that in a hysterectomy they "take out the works," reflecting a belief that the reproductive organs are the essential "works" of the body. In the same vein, the notion was expressed that a hysterectomy "cleans you out," again indicating that essential organs are taken away. A significant number of patients stated that they had heard from friends and relatives, "You're never the same after this operation," which implied an irreversible loss of effectiveness, and a somewhat more optimistic but, nevertheless, irrational belief, "It takes a year to recover from this operation."

Anxieties concerning weakness and inability to function were even more clearly articulated by some women in the immediate postoperative period. One patient reported three months postoperatively, "I still don't have my own strength back." Another stated six months after hysterectomy, "I can't do half the work that I was capable of doing." Another said, "I used to be much faster." Still another stated four months postoperatively, "I tried to work but couldn't make it." A housewife said, "Now I can't even do my own housework. I force myself but I just can't." These frequent complaints were often attributed specifically to the loss of the uterus and reflected the belief that a reservoir of strength and vitality had been irreparably damaged.

OTHER FUNCTIONS ATTRIBUTED TO THE UTERUS

In addition to the above-mentioned functions of childbearing, sexuality, menstruation, and general strength, which were prominently mentioned by patients as dependent upon possession of the uterus, there are a number of less frequently mentioned functions and values attributed to the female reproductive organs. Four women expressed grave concern that the operation would cause an abrupt change in their appearance, particularly the belief that they would age rapidly following hysterectomy. "I'm afraid my skin will get dry and my hair will get gray." Another said, "I hear you lose your youth after this operation." A 47-year-old woman impulsively interrupted the examiner by asking, "Why do they take off women's breasts? I have no lumps. I'd feel awful if they did that to me. I'd have nothing to live on. I'd have no shape." This woman had no symptoms related to her breasts. The examiner was discussing her hysterectomy exclusively, but she was obviously concerned about the effect of this procedure on her appearance and her statement was an indirect way of communicating, "I'm afraid that this operation will affect my shape." Furthermore, it appears that an attractive shape was all she had "to live on," indicating that physical attractiveness was one of the most important feminine attributes in her life.

A few women described anxiety about postoperative pain. "I hear the pain in the incision down there is terrific." She expected a great deal of postoperative pain in her lower abdomen and perineal region because these were the most sensitive parts of her body. She expected much more pain from surgery in this area than she would have expected from surgery performed elsewhere on her body.

One unusual feature of this study, which would not necessarily be true of similar studies performed in other hospitals, emerges from the fact that extensive pelvic surgery is often done at Memorial Center. Although none of the women in this study had such extensive pelvic surgery, they did see on the wards many other women who were required to wear a colostomy bag or who maintained suprapubic urinary drainage. As a result of this situation, patients, in their preoperative interviews, frequently were very anxious about the possible loss of control over urine or bowels. In several patients the fear and disgust over this possible loss of control over excretory functions took precedence over fear of malignancy or fear of loss of sexual or reproductive powers. Even where patients were explicitly informed that they were not to have such extensive surgery they, nevertheless, remained anxious and fearful about anticipated loss of excretory control. One stated, "I'm afraid about the bottle they wear. The worst part about this operation to me is the mess with that bottle." One patient questioned on this subject turned to the examiner saying, "Why do you have to go into that? It's the one thing I don't want to think about." A 31-year-old woman was virtually inaccessible to interviews because of her preoccupation with the subject. She said, "This scares me. I don't want a bag on my stomach. I don't care what they do but I don't want a bag on my stomach. I don't care about not having any children. I'm not worried about dying. All I want is to go home without a bag on my stomach." Another patient said, "I don't want bottles and I don't want to be a cripple." The intimate association between these two fields indicates that she unconsciously viewed the bottle as symbolic of loss of control over her bowels and urine, which, in turn, is associated with being helpless, dependent and crippled. The same woman said, "I won't permit my mother to come here. I'm afraid of her reaction to seeing the sights and the bottles on those people." This patient felt that her mother would be intolerant and disgusted at seeing adults who did not have control over their excretory functions.

There is evidence to indicate that seeing other patients with more extensive pelvic surgery was not the sole cause for the preoccupations with loss of excretory control. Several patients had this preoccupation before admission to the hospital. Other patients talked with anxiety about their friends or relatives who had had the operation elsewhere and afterwards had wet the bed or stained themselves. One woman said, "If they do anything to the pelvic bone I'm afraid it would mean losing control of my bladder." We believe that the proximity of the reproductive and excretory organs and the intimate association and confusion of sexual and excretory processes is responsible for some of the anxieties surrounding impairment of excretory function in patients who had no reason to expect colostomy, cystotomy, or other impairment of sphincteric control.

One fear either expressed or implied by several women was that a hysterectomy would cause them to lose their independence. No single reason was given for this anticipated loss of independence, but rather it was interrelated with several of the functions already mentioned as dependent upon possession of an intact uterus. One woman felt that she would lose her sexual appeal to her husband and that her strategic position in the household would be weakened. Another felt that independence came from her ability to have outside employment and a supplementary income. She felt that the hysterectomy would weaken her, make her unable to earn her supplementary income, render her completely financially dependent upon her husband and, therefore, put her in an inferior position in the family. These instances stress rather dramatically the importance of the uterus and its function to these women as an organ in their total adaptation, and as an instrument for maintaining a balance of forces in their interpersonal relationships.

DISEASE OF THE UTERUS VIEWED AS PUNISHMENT FOR GUILT-LADEN ACTIVITIES

Turning from the specific functions which are attributed to the uterus, there is a body of data relevant to viewing the disease and surgery of the uterus as punishment for guilt. We know from studies of the psychologic impact of other operations that disease or surgery of any organ may be viewed as punishment for guilt-laden activities involving that organ. Several women in this study spontaneously volunteered their views concerning the alleged cause of their uterine disease. Bard and Dyk (2) have exhaustively tabulated and discussed the meaning of the spontaneous beliefs which patients verbalized concerning the alleged cause of somatic illness. They divided beliefs into two large groups, namely, (1) beliefs classified as self-blame, and (2) projected beliefs involving the blaming of others for one's disease. In our study the patients' beliefs were predominantly classified as "self-blame." One woman volunteered, "If I'm in pain I ask, 'What did I do to deserve this? What are my sins?' But I don't know of any sins. Maybe this sickness is a punishment for something I've done, but I don't know what it is." Frequently patients volunteer a specific guilt or mishavior which is singled out to explain their destructive illness. A 35-year-old unmarried woman who developed a serious depression after hysterectomy became excessively ruminative about a sexual relationship she had with a married man. Having become pregnant by him, she had hoped that he would divorce his wife and marry her. But when these events did not take place she had herself aborted and had no subsequent pregnancies. She expressed considerable guilt over the illicit sexual relationship, her deceitful use of pregnancy to win a husband, and her "murderous" disposal of her unborn child. She felt that the hysterectomy was a suitable punishment because it was an assault on her offending sexual organ, it reduced her chances for marriage, and forever eliminated the possibility of having a child. A 38-year-old woman who had been sexually frigid in her first two marriages but who became responsive and sexually active in her third and current marriage, attributed the development of a cervical lesion to excess sexual activity. She felt that she was more passionate than other women, had more frequent sexual contact with her husband and, as a result of this activity, her cervix had been scratched and irritated. Another woman gave a quasi-scientific explanation which intimated her belief that sexual relations were destructive and responsible for her uterine disease. "About eight years ago my husband gave me gonorrhea. I know that's what caused the trouble and led to everything. If they took a tube out eight years ago this would have never happened. Instead, I got warts on the cervix from that gonorrhea and feel that these are the direct cause of my present condition." A 40-year-old woman who was somewhat more sophisticated presented the examiner with a newspaper clipping and stated, "I read an article in which it said that cancer and sex activity are linked in an unexplained way. They call it the marriage factor. They say if a woman is sexually active early in her marriage it leads to cancer of the uterus, and if she's less emotional in her marriage she's liable to get cancer of the breast. Might there be some truth in it?" She added that for years before reading this article she had somehow felt that sexual intercourse might be having a harmful and irritating effect upon her. She described herself as possibly "oversexed" because she had sexual desire and orgasm, unlike so many other women she knew, and felt that this newspaper article supported her previous convictions that sexual activity was insidiously harmful. Still another patient reported, "My husband was careless and I got pregnant. I took some pills and had a heavy flow. Maybe that's it. Maybe those pills caused this condition?"

Two women, who had had as initial symptoms both vaginal bleeding and progressive weakness, attributed their illness to overwork. As has been discussed above, some women viewed the uterus as the seat and source of their physical strength. To them, overwork may be considered equivalent to overdrawing on their "bank account" of strength, and since the uterus was considered to be a depletable source and reservoir of their womanly strength, they felt that their uterine disease was the result of their abuse of their strength-giving organ.

These women who verbalized their private beliefs about the cause of their illness saw themselves as being deprived of their organ of sexuality and, in some instances, their organ of nonsexual feminine effectiveness as a result of "sinful," tabooed, or self-abusive activities. Most, but not all, of the forbidden activities which were seen to lead to punitive loss of this valued organ were sexual in nature.

VULNERABILITY OF THE FEMALE REPRODUCTIVE ORGANS

In several instances where patients expressed no conscious beliefs of guilt-laden activities as a cause of uterine disease, they did volunteer beliefs that the female reproductive organs are the most vulnerable part of a woman's body and, hence, most easily injured or most likely to be the site of disease. Several women felt that this accounted for the high incidence of uterine cancer in the female population. One woman, who developed menorrhagia and metrorrhagia from fibroids shortly after her husband's death, said, "I was very upset after he died. I guess that's why this trouble started. That's where a woman is affected when she has a shock."

We have already described patients who

postoperatively believed (1) that it takes unusually long for surgical incisions of the genital organs to heal, (2) that intercourse, douching and pressure on the lower abdomen had to be avoided because of the excessive fragility peculiar to this region of the body, and (3) that postoperative pain in this area is more severe than pain associated with surgery of any other region of the body.

RELATIONSHIP BETWEEN UTERINE AND GASTROINTESTINAL FUNCTION

Some relationship between uterine function and gastrointestinal function has already been described in the discussions of menstruation as an excretory experience and of anxieties surrounding possible incontinence following uterine surgery. In addition, one woman felt that she lost vitamins as a result of her hysterectomy and put herself on a high vitamin diet to compensate for her loss of this valued nutritional substance. Another, whose husband had become sexually indifferent to her after the operation, stated, "There's no nutrition in this marriage."

A variety of gastrointestinal symptoms occurred in this group postoperatively. Two patients reported prolonged lack of appetite after their return home. One patient had a hysterectomy for a fibroid but was otherwise in excellent physical health. Her lack of appetite was a constant postoperative preoccupation. She reported that sexual relations with her husband had virtually ceased but this was a matter of indifference to her. She then added, "I'm much more worried that I can't eat. That's more important." She indicated that she was excessively preoccupied with her appetite disturbance and that until questioned by the examiner had never given a second thought to her absent sexual relations. One can suspect that this woman, who was highly repressed and fearful in sexual matters, had displaced her anxiety and frustration about the diminished sexual activity from the reproductive to the gastrointestinal tract, and her diminished appetite was a more acceptable method of consciously expressing her sexual deprivation.

We found more commonly, however, that patients complained of excessive appetite in the postoperative period, gained a great deal of weight, and could not bring their apparently compulsive eating under control. A 23-year-old woman who had a hysterectomy for advanced carcinoma of the cervix reported, "I overeat. People say I never stop eating. I'm always hungry, even after a steak dinner." A 30-year-old patient reported, "I've put on a lot of weight. My appetite is too good. I was able to curb my appetite before the operation but not now. I seem to want a lot of sweets." She stated later on, "Both my sister and I ate a lot after this operation. We came home depressed. I guess both of us wanted to put a sweet taste in our mouth to soothe ourselves and make ourselves feel better." She added further insight into this mechanism when she said, "I feel an emptiness, a space in my stomach. It's not a pain and it doesn't bother me, but it's just an empty feeling, like something is missing. I feel that sometimes I eat so much to try to fill this emptiness."

Bowel irregularities and inability to tolerate certain foods were reported less frequently than appetite disturbances. One woman, who had become constipated postoperatively, stated, "Even when I take an enema and get things loosened up I never get the satisfaction from a movement." Further questioning and rectal examination revealed that the patient had apparently adequate bowel movements from the standpoint of evacuation, but that she did not have the feeling of satisfaction that had previously been associated with a normal bowel movement. This woman had had no sexual activity since her operation. She reported that her vagina felt like it was swollen and constricted. As a result she had a great deal of pain inserting a douche nozzle. The feeling of constriction in the rectum was very much like the constricted, swollen, painful feeling in her vagina. The gynecologic examination revealed no abnormality of the vagina, and it became clear that her rectal as well as her vaginal symptoms were subjective reactions to her hysterectomy.

We feel that many of the gastrointestinal disturbances following hysterectomy stem predominantly from emotional rather than physiologic factors. We know that gastrointestinal and sexual functions are frequently interrelated in the mind of a child. The anatomic proximity of the vagina and the rectum and bladder may lead to confusion and distortion and inability to psychologically separate the two organs when one is affected. Psychoanalysts are well aware of the notion of "babies coming from the stomach" and fantasies of oral impregnation in childhood. Sexual desire and nutritional desire are frequently described as "appetites." Sexual anxieties and frustrations may be expressed as apparent disturbances of nutritional function. The cloacal theory of female anatomy, which recognizes only one opening in the perineal region and which confuses the child with feces and identifies childbirth with defecation is one of the traditional psychoanalytic observations of the interchangeability of uterine and gastrointestinal symptoms. Our findings of gastrointestinal and reproductive interrelatedness, and especially the development of many unphysiologic gastrointestinal symptoms following hysterectomy, are interesting in this context.

DISCUSSION OF GENERAL PSYCHOLOGIC CONCEPTS

We have accumulated in this research additional data which support the general psychologic concepts derived from previous studies of the psychologic impact of cancer and cancer surgery. (1) Previously unconscious or denied fears became conscious and easily verbalized. One woman stated, "I always thought I'd be brave about an operation. I thought I'd need just a few weeks rest and I'd be my old self again. Now that it's about to happen I've got all kinds of worries about whether I'll ever be able to do all my work again and whether my husband will be the same after this." (2) Heretofore unformulated personal beliefs about the anatomy and physiology of specific organs came to awareness with disease or surgery to that organ. A woman said, "You just don't think about things like your womanly organs until they give you trouble." (3) Adaptational patterns became readily apparent in reaction to the stress of disease or surgery. A 38-year-old woman had always considered that her value as a person and acceptance as an individual was based on her service to her husband, son and employers. Immediately after hysterectomy she felt compelled to make herself helpful on the hospital ward. She insisted on helping the nurses and serving meals to other patients, although such help was not solicited and, at times, was discouraged. Another patient became engaged in frantic cleaning at home, an exaggeration of her preoperative housekeeping habits, in order to "prove to myself I can still do it."

DISCUSSION OF THE PSYCHOLOGIC IMPORTANCE OF THE UTERUS, THE MEANING OF FEMININITY, AND THE CONCEPT OF CASTRATION IN FEMALE PSYCHOLOGY

The psychologic importance of the uterus can best be understood in terms of the conscious and unconscious ideas which each woman has about her uterine anatomy and physiology. These beliefs are derived from the woman's knowledge of the realistic function of this organ, as well as her personal and individual concepts of uterine anatomy and physiology derived from her individual developmental experiences. These assumptions—both realistic and unrealistic—determine the manner and extent to which the uterus and its functions have been organized in the total adaptational pattern of each woman. These assumptions determine the form and intensity of the fears which often develop when the uterus becomes diseased or requires surgery. These assumptions contribute to the emotionally induced symptoms which develop postoperatively when possession and function are lost. These assumptions determine to what extent the uterus and its functions are regarded by each individual woman as necessary for effective functioning as a female. This, in turn, determines to what extent patients feel their femininity is reduced or damaged by disease or surgery to the female reproductive organs.

It is probable that every woman has certain concepts (which may or may not be consciously formulated) of what constitutes femininity and what anatomic structures are related to femininity. We recognize that many women regard the uterus and its functions as important symbols of femininity. Attitudes expressed by a woman towards the uterus and its real or imagined functions should be regarded as specific expressions of her attitudes towards herself as a woman and her feminine role in life. The women interviewed in this study illustrate how intimately the uterus was related to their concept of femininity and how the loss of the organ was experienced as an injury to their femaleness.

Although femininity may be differently defined by many different women, it appears to be regarded by most as a highly valued quality in their adaptation to life. There is no evidence in this study to support the thesis that a woman regards her femaleness with resignation or with reluctant acceptance of a role considered inferior to that of a male. In whatever form it may be understood, femininity is a positively valued quality, and perception of its loss is a serious, threatening event in a woman's life. Loss of the reproductive organs produces loss of feelings of femininity in many women.

In view of these findings, we suggest that the psychoanalytic concept of "castration" in the psychology of women should be considered to contain elements which are similar but not exactly identical to the traditional psychoanalytic concept of "castration" in the psychology of males. In both sexes the individual has an idea of what constitutes masculinity or femininity, respectively. In both sexes these ideas are derived from the commonly held concepts of the culture, as well as the privately held notions derived from the individual developmental experiences. In both sexes these ideas are related to sexual anatomy. In both males and females the sexual organs and their functions may often be the focus of doubts about one's adequacy as a member of one's own sex group. The sexual organs are frequently seen by persons of either sex as peculiarly vulnerable to injury or disease. Both men and women may unconsciously fear that the sexual organs will be the site of punishment for guilt-laden activities. In both sexes the sexual organs may be symbolically utilized to express a variety of attitudes, positive or negative, towards the self and members of one's own sex. When we surgically remove or threaten to remove the reproductive organs, attitudes emerge which are a combination of (1) a realistic reaction to the real physiologic impairment that may result from loss of the organ, and (2) irrational concepts and attitudes connected with the symbol.

We suggest that the psychoanalytic concept of "castration" for either sex includes a real or fantasied mutilation of subtraction of a valued organ (or its symbolic equivalent) which is viewed as necessary for optimal function as a member of one's own sex. Loss or injury to this organ may be conceived as rendering the individual less effective or totally ineffective in both sexual and nonsexual activities which are viewed as uniquely male or female, respectively. We do not imply that the uterus should be regarded as psychologically exactly equivalent to the penis, although in individual instances of severe psychopathology, such as the woman with recurring swelling of the abdomen mentioned above, the uterus and penis are so regarded. The realistic function of the penis and the uterus in masculine or feminine activities are different. The uniquely male and uniquely female activities, both sexual and nonsexual, are significantly different. Specifically, loss of the uterus does not terminate the possibility for sexual intercourse, while loss of the penis obviously does. Therefore, in suggesting a broader definition for "castration" in psychoanalytic psychiatry, we caution that the threat of the loss of penis and the threat of the loss of the uterus and their respective functions must be regarded as somewhat similar but not exactly analogous threats. "Castration anxiety" is comprehensible as a fear related to a threat to the integrity of the sexual organ or its symbolic equivalent for either sex. The significance of this "castration anxiety" can only be understood in the context of the real and imagined importance of the sexual organs and sexual functions in the total adaptation of the individual.

SUMMARY

1. A group of 23 premenopausal women who had undergone hystèrectomy was studied to determine the importance of possession of the uterus in female adaptation.

2. The cultural and individual concepts of femininity were discussed and the importance attributed to the uterus in maintaining the uniquely female functions was described. Of the variety of functions attributed to the uterus each was valued differently, depending on the total adaptational pattern of the patient.

3. Most women viewed the uterus as one or more of the following:

(a) Childbearing organ

(b) Excretory organ

(c) Regulator and controller of body processes

(d) Sexual organ

(e) Reservoir of strength and vitality

(f) Maintainer of youth and attractiveness.

4. Disease or surgery of the female genital organs was sometimes viewed as punishment for guilt-laden activities involving these organs, chiefly, but not exclusively, sexual activities.

5. Theoretical implications:

(a) The uterus is regarded by many women as an important symbol of femininity, onto which is projected attitudes towards sexual and nonsexual female functions.

(b) It is suggested that "castration" in the psychoanalytic psychology of both sexes may be regarded as a threat of injury to the unique organ of sexuality and to the kinds of effectiveness identified with each sex.

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SOMATO-PSYCHOTHERAPEUTIC APPROACH TO LONG-TERM SCHIZOPHRENIC PATIENTS: THREE YEAR EVALUATION

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In a previous report (2) we described a six month demonstration program of comprehensive psychiatric care designed to improve the behavioral adjustment of long-term schizophrenic patients. This program was conducted in a general medical hospital setting with approximately 200 beds allocated to long-term psychiatric patients.

Ten experimental and ten control patients, all with exceptionally poor prognoses, were matched individually for age, chronicity, and ward adjustment. Mean age was 56.2 years for the demonstration group and 58.6 for the controls; mean chronicity (years since first hospitalization) was 26.7 and 26.9 years respectively. Their initial levels of ward adjustment were equivalent: the mean Behavioral Rating Scale score (1, 2) was 40.8 (of a possible 100) for the demonstration patients and 40.0 for the controls. All available rehabilitation procedures were *intensively* applied to the demonstration group. The control patients proceeded with their usual ward programs. The experiment was terminated at the end of its 26th week (six months duration).

Objective ratings were made throughout the six month course of the experiment, and were quantitatively analyzed. They demonstrated a significant degree of behavioral improvement in the experimental patients. The control patients made no such improvement and even showed a slight deteriorative trend although this trend did not attain statistical significance.

The present paper reports the results of a three year follow-up study on these same patients. At the conclusion of the original demonstration program, and based upon our experiences with it, a similar type of comprehensive program was gradually instituted for all long-term patients in the continued treatment section.

This expanded program was necessarily less intensive than its original counterpart, and did not include all the innovations such as full social and ward intermingling with the younger neurotic patients. Nor did the various (and now numerous) staff participants attain that high pitch of enthusiasm which had been so prominent in the original demonstration program. On the other hand, additional kinds of activities were made available to the patients. These included appropriate programs devised and executed by educational therapist and hospital librarian. Chlorpromazine and reserpine had become available and were prescribed by ward psychiatrists to all patients for whom there was no medical contraindication. Patients were maintained upon these drugs so long as they were clinically beneficial.

Hence, demonstration and control patients began to receive equivalent rehabilitation treatment following termination of the experiment. For the former this meant a watering down of their previously intensive and multi-faceted program, but for the controls it meant an increased emphasis upon comprehensive treatment.

RESULTS

Three years after the midpoint of the original experiment (or 33 months from its termination), sixteen of the twenty patients were still available in this hospital for follow-up study. In the interim two experimental and one control patient had died of natural causes and one control

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TABLE 1

Intergroup Comparisons of Original Demonstration (D) and Control (C) Scores on Behavioral Rating Scale

Original Group	Pre-Experiment	6th Experimental Month (Termination)	Follow-up 33 Months Later
D mean score (N = 10)	40.8	51.0	46.0 (N = 8)
C mean score (N = 10)	40.0	31.7	44.8 (N = 8)

patient had been transferred to another hospital for active tuberculosis.

These sixteen patients (now eight experimental and eight controls respectively) were reevaluated by means of the Behavioral Rating Scale. Table 1 presents the follow-up results (see column 4). The initial (pre-experiment) and terminal results of the original experiment are also presented in Table 1 for comparison.

It is apparent that the demonstration group lost ground while the controls gained. Thirty-three months post-experiment, both groups are once more side by side with approximately equal levels of adjustment. However, they have met at a point above their initial pre-experimental level (mean scores now 46.0 and 44.8 respectively as against 40.8 and 40.0 initially).

The original demonstration and control groups had been matched in pairs, patient for patient. All four patients now lost to us came from different matched pairs. It was therefore theoretically possible that, by chance, the follow-up change in status of the two groups was merely a reflection of the accidental loss of particular patients such as to penalize or lower the demonstration group mean score while raising the control group mean score.

TABLE 2

Intergroup Comparisons of Reconstituted Demonstration (D) and Control (C) Scores on Behavioral Rating Scale

Reconstituted Group	Pre-Experiment	6th Experimental Month (Termination)	Follow-up 33 Months Later
D mean score (N = 8)	40.6	53.8	46.0
C mean score (N = 8)	41.0	34.8	44.8

In order to check upon this possibility the Behavioral Rating Scale records of the sixteen survivors (eight in each group) were traced back to the beginning of the experiment. The original demonstration and control groups were then reconstituted on the basis of the eight surviving members from each group; those who now constitute the basic of follow-up. The group mean scores (N = 8) were recalculated for their pre-experimental status and their status at the sixth experimental month (termination). These means, together with the 33 month follow-up means for the (now the) same patients, are presented in Table 2.

Comparing the pre-experimental status of the original (N = 10) with reconstituted (N = 8) groups, we note but minimal difference. The directions and relative degrees of change (demonstration versus control) are equivalent whether N = 10 or N = 8. It has not been feasible to make significance tests based upon the sample size N = 8, for the sample is too small (and hence the standard error too great) to yield meaningful results.

Figure 1 gives a diagrammatic representation of the changes in behavioral adjustment reported in Table 2. It emphasizes the final common meeting point at follow-up,

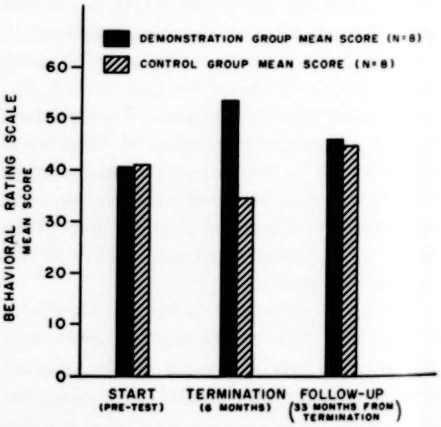

FIG. 1. Comparative changes in behavioral adjustment at three year follow-up.

after an earlier marked divergence instigated by the experimental treatments.

DISCUSSION

Three years later, the original demonstration and control groups have converged to approximately the same adjustive level. This level is a distinct improvement over the initial pre-experimental stage. While it is only half as good as the point attained by the demonstration group at termination (33 months earlier), it is considerably better than the adjustment level of the control group at that termination. The controls have even been able to *reverse* their deteriorative trend in moving upward to a level of adjustment which is superior to their initial status.

These follow-up results might be variously explained. It seems to us most reasonable to infer that intensive, comprehensive treatment, enthusiastically given, yields the greatest increment in behavioral improvement. The less intensive the treatment or the narrower its scope, and the less enthusiastic the staff participation, the smaller the degree of improvement. The intensive and full treatment program did improve the experimentals, while a routine and merely "adequate" program gave unsatisfactory results for the controls. When the controls were later given a comprehensive program they showed consequent good improvement at follow-up. The experimentals, for whom this same program now constituted a *less* intensive effort, consequently showed some loss at follow-up. In both cases however, demonstration and control, this program was superior to the initial pre-experimental treatment program: hence the increase in adjustment above that initial level for both.

The natural deteriorative tendencies in the older schizophrenic age groups, caused by the disease and/or long years of hospitalization, may be decelerated or even reversed: as witness these results. However, a merely adequate hospital care program is probably not sufficient to yield such benefit. The program must be vigorously and enthusiastically pursued, and every attention given to the interest and morale of staff participants. Formal and informal conferences, an atmosphere of cooperation among colleagues unimpeded by authoritative hierarchy considerations, and the engendering of a sense of pride in the accomplishments of patients *and* staff as a unitary group, all these heighten the interest and morale of participants. They are vital to the program and necessary for the best interests of the patients.

The findings from this experiment and its follow-up may be expressed succinctly: the greater the rehabilitative effort the greater the rehabilitative effect. This maxim, simple as it appears, requires reiteration in a period when we seek powerfully to establish *the* basis for the etiology and treatment of schizophrenia. Effective treatment tools are already available to us. Let us use them extensively and with enthusiasm. Even for the most chronic schizophrenias, doubly complicated by problems of age, they can yield behavioral improvement.

SUMMARY

This is a three-year follow-up report of the adjustment status of hospitalized long-termed schizophrenic patients who had participated in a controlled experimental program of six months duration. Comprehensive and intensive rehabilitation therapy had been given to the experimental group whereas the control group had received its usual ward treatment program. Both groups had been at the same level of adjustment prior to the experiment. At its termination, the experimental group had shown significant improvement in adjustment while the control group had shown tendency toward deterioration.

At the conclusion of the experiment the patients of both groups began to receive equivalent treatment procedures. These were superior to the procedures which the controls had received but inferior to those which the experimentals had received. Three years later, according to the ratings of a Behavioral Rating Scale, the experimental patients have shown some loss but not to their initial pre-experimental level. The control group has reversed its deteriorative trend and has gained to a level above its initial pre-experimental level. At this three-year evaluation study the two groups have met and are once again at approximately the same level of behavioral adjustment, but a level well above that of the pre-experimental status for both

The extent and vigor of the psychiatric rehabilitation program determined the rehabilitative results. The implications of this were discussed.

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FREUD AND EXISTENTIALISM

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Paul Tillich has cited as basic to all forms of existentialist thought four concepts: freedom, finitude, anxiety, and nonbeing (26). These existentialist concepts appear in Freud's writings covertly and against a radically non-existentialist background. In the following pages, we shall try to show (a) the anti-existentialist, mechanistic conceptual framework that dominated Freud's initial approach to the study of man; (b) how at various points Freud was forced to transcend this framework in the direction of a phenomenalistic approach based upon the postulate of freedom; and (c) how Freud's analysis of anxiety, narcissim, and the pleasure-principle approximates the existentialist analysis of finitude, anxiety, and nonbeing.

I.

Freud's general position was scientism. He was convinced that science is the only source of knowledge. In his words, science embraces "the whole field of human activity as its own" and must adopt "an uncompromisingly critical attitude" toward any other cognitive enterprise—*viz.*, religion or philosophy—"that seeks to usurp any part of its province" (**17**, pp. **203–5**). Freud's conception of correct scientific method, so far as the study of neurosis was concerned, was furnished by nineteenth century German psychiatry, which Dr. Robert K. Knight has characterized as "still dominated by the neurological approach as epitomized in Griesinger's dictum 'Mental Diseases are brain diseases' " (**22**, p. **777**; cf. **1**). This neurological approach, however, was almost useless for comprehending or controlling abnormal behavior. Freud described the situation by saying

> ... the work of the greatest name in German neuropathology (W. Erb's textbook on electrotherapy) had no more relation to reality than some "Egyptian" dream-book such as is sold in cheap book-shops (10, p. 27).

And it was as a practicing therapist that Freud found himself required to introduce purely psychological explanations and psychological therapy.

Freud felt uncomfortable over his departure from physical explanations and felt constrained to justify to his medical colleagues the very existence of psychoanalysis (**13**, pp. **250** ff., **9**, pp. **17–9**, **75–6**). He offered a practical justification and a theoretical one. Pragmatically, psychoanalysis works. The existing neurological and physiological explanations do not (**9**, pp. **21–2**, **342–4**). Psychoanalysis must therefore break with all existing physical explanations and develop its own psychological concepts. On the theoretical level, Freud justified this procedure by designating psychoanalysis a stop-gap enterprise, a preamble to true causal explanation.

> The edifice of psychoanalytic doctrine which we have erected is in reality but a superstructure, which will have to be set on its organic foundation at some time or another; but this foundation is still unknown to us ... (9, p. 338; Cf. 15, pp. 135–6).

The above-cited conception of physical explanation as canonical and of psychoanalysis as a kind of temporary adjunct to biology and biochemistry influenced Freud's entire approach to neurosis and human nature. Freud wished not only to correlate psychological explanations with physical explanations (or, to put it another way, to correlate psychological and physical causality), but also to model his psychological concepts on physical or biological concepts. He sought to show that his psychological concepts were derived from biological principles. He conceived the instincts as "the psychological concomitants of biological processes," (17, p. 125). He worked out a "topography" or "anatomy of the mental personality" with metaphorical regions for different functions, and sometimes even sought anatomical counterparts (18, pp. 28–31). And in the technical language he developed, the libido was conceived after the analogy of an electric current (13, p. 75; 12, p. 48, footnote).

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In general, Freud thought that the human personality, so far as it was amenable to psychoanalytic investigation, should be conceived in terms of a mechanical model. The psyche, so far as psychoanalytic inquiry is concerned, is to be conceived as consisting of various forces, variously located, moving in various directions: the repressed forces moving upward from the unconscious, the repressing forces pushing them back down; the various instincts (sex and ego; in a later theory, life and death) striving for satisfaction, combining with and separating from other instincts (fusion and defusion). Out of the various movements there is compounded by a kind of psychic parallelogram of forces the complex movement which is the overt, conscious behavior. By an understanding of the forces at work and the laws of displacement and combination, this complex behavior may be reduced to its elements.

The specific dispositions and movements of the instinctual forces in a given individual are determined by physical events occurring in the environment or by the hereditary structure of the organism. These factors determine not only symptoms and phantasies, but the entire character structure, whether normal or neurotic. Any subsequent change in the psyche can take place only through the operation of counter forces. In psychoanalytic therapy, the analyst throws his weight on the side of the beneficent forces and, if the quantitative factor is right, tips the scales against the pathogenic factors. The analyst, like a surgeon, discovers the pathogenic factors, isolates them, and removes them.

The teleological element in human behavior is reduced to a minimum. The goals pursued by man are the satisfaction of biological drives. These drives may get deflected, refracted, and compounded so that the directly pursued goals are the so-called higher or spiritual aims, but these spiritual values—art, religion, philosophy, even science itself as an end—are substitute formations, sublimations, or "aim-inhibited" impulses. The satisfaction of the drives brings pleasure—or is pleasure. Reason, human intelligence, has a purely instrumental, utilitarian function. It provides no new goals. It merely enables man to carry on the quest for pleasure more realistically, to satisfy his biological needs (in their crude or "sublimated" form) more expeditiously (16, p. 18).

The approach schematized above is based upon the Cartesian dichotomy. Man is a biological organism, really a machine, *res extensa.* The psychic forces that psychoanalysis speaks of are the shadows, the epiphenomena, the "psychological concomitants" of physical energy. Superimposed upon this machine is the human mind, *res cogitans.* This mind is constituted by technical (*i.e.,* logico-mathematical) reason, which discovers sequences and connections, and enables man to manipulate the mechanism governing human life. Completely absent in this scheme is any concept of spirit or subjectivity, any concept of the ontological function of reason as the pursuit of the Logos, of the "meaning of life." All those functions of the human mind that are not purely rational in the narrow sense of the word are to be understood in terms of subrational biological or mechanical principles.

It is precisely this reduction of the spiritual to the subspiritual that existentialists of all ages have protested against.

> The existing subject is neither *res cogitans* nor *res extensa,* nor can it be identified with a chaotic realm of mere emotions. It has a structure which can be analysed.... It is the analysis of this structure of existing subjectivity to which existentialism in all its forms, within and outside of pure philosophy, has dedicated itself (26, pp. 741–2).

The existentialists seek to develop categories of explanation that are adequate to the full, concrete richness of selfhood, categories that are autonomous and that have their justification in their empirical adequacy, not in their analogical conformity to mechanical biological principles. In the remaining pages we shall try to show how Freud was compelled at certain points, by the exigencies of his empirical inquiry, to abandon his Cartesian presuppositions and to develop concepts similar to those of the existentialists.

II.

In this section we shall try to show where Freud approximates the existentialists' concept of freedom. The first point to note is the complete breakdown in practice of Freud's postulate of Determinism. Freud's original theory of neurosis postulated sexual experiences in early childhood, involving actual stimulation of the genitalia, as the cause of neurosis (13, pp. 148–54). Between the years **1896** and **1905** Freud discovered, to his great dismay, that in many cases, the alleged traumatic sexual experiences which his patients had been able finally to "remember" after months of analysis had in fact never occurred (10, pp. 59–60, 13, pp. 299–300, 9, pp. 320–324). They were pure phantasy. It made no difference in the etiology and structure of the neurosis whether the childhood experiences were real or imaginary. And, in general, there was no significant difference between the childhood environments of the normal and neurotic adults.. The important thing was the subjective reaction of the child, the meaning he attributed to the event. As Freud put it, "psychic reality" was more important than "physical reality" (9, p. 322, 10, p. 61). And Freud concluded:

> ...childhood experiences of this kind are in some way necessarily required by the neurosis,... they belong to its unvarying inventory. If they can be found in real events, well and good; but if reality has not supplied them they will be evolved out of hints and elaborated by phantasy. The effect is the same, and even today we have not succeeded in tracing any variation in the results according as phantasy or reality plays the greater part in these experiences (9, pp. 323–4).

With this concept of "psychic reality," Freud approached the phenomenological method of existentialism, in which the meaning of the fact for the subject is the primary datum. Freud might have accepted the fact of differing subjective reactions to childhood experiences as an ultimate given, as something not explainable in terms of any etiological factors. He would then have approximated the existentialist notion of the choice of a fundamental "project" or way of relating oneself to reality, as, in fact, Alfred Adler did in his notion of the individual's style of life (cf. 22). But true to his physicalist assumptions, Freud sought hereditary factors that could cause the differing subjective reactions, and also cause the phantasies about childhood events.

Freud postulated certain traumatic events in the prehistoric past of mankind, involving the murder by the "sons" of the father-leader of the "primal horde." These events produced pathological conditions in the psyches of the "sons," which are transmitted from generation to generation as an "archaic heritage" of phylogenetic memories (6, pp. 915 ff., 10, pp. 124–6, 7, pp. 126–31, 154–60).

> In them the individual, wherever his own experience has become insufficient, stretches out beyond it to the experience of past ages. It seems to me quite possible that all that today

is narrated in analysis in the form of phantasy, seduction in childhood, stimulation of sexual excitement upon observation of parental coitus, the threat of castration—or rather, castration itself—was in prehistoric periods of the human family a reality; and that the child in its phantasy simply fills out the gaps in its true individual experiences with true prehistoric experiences (9, p. 324).

Freud consistently maintained the importance of this phylogenetic component, rating it above all environmental influences (**18**, p. 66), even though he realized that the idea of mankind originally living in hordes was contrary to the opinion of most anthropologists and that his idea of an "archaic heritage" contradicted a basic tenet of biology; the non-inheritance of acquired characteristics (**7**, pp. 158, 207–8). His physicalist assumption required real, physical threats to generate the pathological reactions; failing to find these threats in the childhood of his patients, he concluded they must have been present in the childhood of the human species.

Apart from its general implausibility, the "archaic heritage" theory fails in principle as an etiological explanation. Even if we grant the correctness of Freud's doctrines of fixation, repression, and recovery during analysis of infantile memories, all this merely shows these elements to be necessary factors in every neurosis. Given the symptoms of an adult neurosis, you can be sure you will find dissociated fragments of childhood "experiences." What Freud needs is some set of factors present prior to the outset of the symptoms which will enable preduction. And Freud was unable to find any factors whose occurrence was invariably followed by neurosis, and in whose absence neurosis never occurred.

Ernest Jones put the matter succinctly:

> Freud has recently commented on the remarkable fact that we are even yet (1929) not in a position to give a satisfactory answer to the apparently simple question of why one person develops a neurosis and another does not (21, p. 458).

And Freud himself quite candidly says:

> So long as we trace the development (of a mental process) backwards, the connection appears continuous, and we feel we have gained an insight which is completely satisfactory or even exhaustive. But if we proceed the reverse way, if we start from the premises inferred from the analysis and try to follow these up to the final result, then we no longer get the impression of an inevitable sequence of events which could not have been otherwise determined. We notice at once that there might have been another result, and that we might have been just as well able to understand and explain the latter....

At this point Freud is in practical agreement with the existentialists, but then he goes on to add that "It is very easy to account for this disturbing state of affairs." It is due to our ignorance of the qualitative factors in their entirety and, beyond that, of the quantitative amounts of these factors. "We can only say at the end that those which have succeeded must have been stronger" (**14**, pp. **226–7**; cf. **13**, pp. 126–8).

Thus, by Freud's own admission, psychoanalytic explanations work backward in time. They trace interrelationships between the neurotic pattern in the adult and the proto-neurotic reaction of the child (infantile neurosis). But the initial reaction is not causally related to any known antecedent factors. Every stage in the development of the neurotic pattern—if we accept Freud's own account of the situation—is optional. Once a step has been taken, we can trace its relations with the past; but we cannot predict. Freud's assumption that if we knew enough about the qualitative and quantitative factors we would be able to predict remains a pure conjecture, or, more precisely, a deduction from his deterministic premise. The proof of the premise is not established by anything in Freud's actual psychoanalytic enterprise. So far as any evidence presented by Freud is concerned, the existentialist assumption of an uncaused, free choice is just as plausible.

√ A more positive approximation to the concept of self-determination or freedom occurs in Freud's treatment of three topics: motives for neurosis, the problem of responsibility, and the nature of therapy. Freud's original position on the topic of motives is stated in his Dora case (written in 1909):

> A *motive* for being ill is sharply to be distinguished as a concept from a *liability* to being ill,—from the material out of which symptoms are formed. The motives have no share in the formation of symptoms, and indeed are not present at the beginning of the illness. They only appear secondarily to it (14, p. 53).

But in the very next paragraph, Freud goes on to discuss the motives for being ill!—as he admits in a footnote added to the Dora case in **1923**. And throughout his writings we find references to the purpose of a neurosis (15, pp. **336–7**; **16**, pp. 13, 162; 14, p. **227**). The awareness of this teleological factor is theoretically acknowledged in the concepts of "primary gain," the purpose for which the neurosis develops, and "secondary gain," the advantage gotten from the neurosis after it has been established (**13**, pp. **341–2**, 15, pp. **53–4**, footnote 1, **19**, pp. **331–5**). This idea of a teleological factor not only imperiled Freud's postulate of mechanism but also involved acknowledgement of the correctness of Alfred Adler's insistence that the neurotic character was the cause, not the consequence of neurosis (9, p. **331**). Freud advised his followers to recognize "the practical importance of the advantage through illness, and yet not to be too much impressed by its theoretical significance," (**19**, pp. **334–5**) and he interpreted the ego-gains "economically" in terms of compromise instinct satisfaction. However, as we shall try to show in the next section, Freud in his actual treatment of narcissism not only approaches the existentialist (and Adlerian) holistic, voluntaristic conception of the *genesis* of neurosis, but also approaches a non-biological conception of *motivation*; that is, neurosis becomes a way of relating oneself to reality.

It was during the years **1914–1920**, when Freud was working with the concepts of ego-libido and object-libido (the period of the so-called "second theory of instincts") that his thought was, in general, closest to the existentialists' voluntarism. With the working out of his final "topography" of superego, ego, and id, in **1922**, the triumph of the reductive, mechanical approach seemed assured. Freud frequently appeared to conceive of the ego as nothing but a pawn, moved by the instinctual forces, reacting "economically" to the dynamic movement of impulse and the "topographical" stresses of superego and id. And it seemed to many critics (and to some adherents) of psychoanalysis that Freud, through his determinism, had absolved man from all moral responsibility.

Thus Jean-Paul Sartre says that "by the distinction between the 'id' and the 'ego,' Freud has cut the psychic whole into two. I *am* the ego but I am not the id" (**24**, p. **213**). "My unconscious is external to me in the way it is external to the physician analysing me." Sartre then cites Freud's remarks about resistance as a proof that the ego is in some way aware of the repressed material (**24**, pp. **215–17**). He says:

> If we reject the language and materialistic mythology of psychoanalysis, we perceive that the censor in order to apply its activity with discernment, must know what it is repressing. In fact if we abandon all the metaphors representing the repression as the impact of blind forces, we are compelled to admit that the censor must choose and in order to choose it must be aware of so doing (24, p. 218).

He adds:

> It (the censor) must be the consciousness (of) the drive to be repressed, but precisely *in order not to be conscious of it*. What does this mean

if not that the censor is in bad faith? (24, p. 219)

And he concludes:

> How can the repressed drive "disguise itself" if it does not include (1) the consciousness of being repressed, (2) the consciousness of having been pushed back because it is what it is, (3) a project of disguise? No mechanistic theory of condensation or of transference can explain these modifications by which the drive itself is affected, for the description of the process of disguise implies a veiled appeal to finality (24, p. 221).

Freud himself acknowledged, long before Sartre, the dangers involved in pan-determinism. He takes explicit exception to the complete "objectification" of the psyche which seemed to be involved in his metapsychology. In a discussion of moral responsibility for dreams, Freud states:

> Obviously one must hold oneself responsible for the evil impulses of one's dream ... Unless the content of the dream (rightly understood) is inspired by alien spirits, it is a part of my own being ... and if, in defence, I say that what is unknown, unconscious, and repressed in me is not my "ego," then I shall not be basing my position on psychoanalysis....
>
> It is true that in the metapsychological sense this bad repressed content does not belong to my "ego"—that is, assuming that I am a morally blameless individual—but to an "id" upon which my ego is seated. But this ego developed out of the id, it forms with it a single biological unit, it is only a specially modified peripheral portion of it, it is subject to its influences and obeys the suggestions that arise from the id. For any vital purpose, a separation of the ego from the id would be a hopeless undertaking (19, pp. 156–7).

Freud goes on to say that if for "the purposes of moral valuation, "I sought to 'disregard the evil in the id' and to 'not make my ego responsible for it,' I would still find myself psychologically compelled to acknowledge my guilt. The person who pretends to be 'better' than he was created will attain nothing more in life than "hypocrisy or inhibition." And Freud concludes:

> The physician will leave it to the jurist to construct a responsibility that is artificially limited to the metapsychological ego. It is notorious that the greatest difficulties are encountered by attempts to derive from such a construction any practical consequences not in contradiction to human feelings (19, p. 157).

Here, and in a few other places (Cf. 18, pp. **71–83**, **15**, pp. **29–30**, **9**, pp. **290–1**), Freud anticipates Sartre's criticism of the mechanistic interpretation of Freud's "topography." Freud, like Sartre, in effect accuses anyone using the metapsychological distinction between ego and id as a basis for avoiding responsibility of being in "bad faith." Indeed, in the above passage, and the others cited, Freud approximates the existentialists' concept of tragic or existential guilt which stems from man's very existence rather than from moral lapses. That is, far from replacing the concept of determinism, Freud extends it beyond the range recognized by legalists and abstract moralists to include the unconscious, vital substructure.

In his conception of psychoanalytic therapy, Freud in a general way moves from a mechanistic position toward a more holistic, voluntaristic one. Originally, Freud conceived psychoanalysis as an art of interpretation, in which the analyst like an archeologist, reconstructed the past from the present fragments. Neurosis was conceived rope-wise. The analyst unraveled each strand and traced it back to its original causes—this symptom to this infantile trauma, that dream-content to that fixation point. When the reconstruction was completed and the patient was informed, and recovered his forgotten childhood memories, he was supposed to be cured (14, p. 362, 366, 19, p. 248). Freud was forced to modify his conception in three important respects. First, Freud discovered "there are various kinds of knowing, which psychologically are not by any means of equal value" (9, p. 249). The technical, factual knowledge which the analyst acquires and passes on to the patient is not sufficient. "The patient has learned something that he did not know before—the meaning of his symptom—and yet he knows it as little as ever.... The √necessary condition is that the knowledge must be founded upon an inner change in the patient which can only come about by a mental operation directed to that end" (9, p. 249).

"This disconcerting ability in patients to combine conscious knowledge with ignorance" Freud explained "topographically." "The patients are aware, in thought, of the repressed experience, but the connection between the thought and the point where the repressed recollection is in some way imprisoned is lacking" (14, p. 363, 9, p. 379). Or as he put it in a later article:

> The forgetting of impressions, scenes, events, nearly always reduces itself to "dissociation" of them. When the patient talks about these "forgotten" matters he seldom fails to add: "In a way I have always known that, only I never thought of it" (14, p. 367).
>
> ...In the manifold forms of obsessional neurosis particularly, "forgetting" consists mostly of a falling away of the links between various ideas, a failure to draw conclusions, an isolating of certain memories (14, p. 368).

This recognition by Freud of a non-technical, non-objective knowledge, an insight by the patient into the subjective meaning of his activities, lead him to a second change in his conception of therapy: the main objective now becomes discovering and eliminating the resistances that call forth and support the "ignorance." When the resistances have been overcome, the repressed "infantile memories" are recovered automatically (14, pp. 288, 302, 363, 366–7, 9, p. 257). The notion of the centrality of resistances lead to the third notion, the analysis of the patient's character. As Freud put it:

> When the physician is carrying out psychoanalytic treatment of a neurotic, his interest is by no means primarily directed to the patient's character. He is far more desirous to know what the symptoms signify, what instinctual impulses lurk behind them and are satisfied by them, and by what transitions the mysterious path has led from these impulses to those symptoms. But the technique which he is obliged to follow soon constrains him to direct his immediate curiosity towards other objectives. He observes that his investigation is threatened by resistances set up against him by the patient, and these resistances he may justly attribute to the latter's character, which now acquires the first claim on his interest (16, p. 318).

In his notion of the two kinds of knowledge, Freud comes very close to the existentialist distinction (to use Paul Tillich's language) between technical reason (controlling knowledge) which is concerned with discovering spatio-temporal-causal relations among things for the purpose of prediction and control and ontological reason (uniting knowledge), which is concerned with insight into subjectivity and selfhood. In his notion of character-centered resistance and dissociation, Freud comes close to the existentialist distinction between unauthentic, hypocritical existence in bad faith, and authentic, resolute existence.

III.

The existentialist concept of "finitude" is approximated in certain features of Freud's analysis of the "two principles of mental functioning" (pleasure-principle and reality-principle) and his analysis of narcissism. The pleasure-principle is a blind drive for immediate pleasure, for satisfaction of instinctual demands without regard to conditions or consequences. The pleasure-principle is absolutely dominant in the infant. In the sexual instincts, it manifests itself in auto-erotism; in the ego-instincts, as the ego-attitudes of "omnipotence" and "wishful thinking."

√ Soon after birth, the pleasure-principle is threatened by the demands of external reality (16, pp. 14–7). The individual is forced to give up both the technique of wishful thinking as a means of self-preservation and auto-erotism as a means of sexual satisfaction (19, p. 310). The infantile "pleasure-ego" develops into a "reality-ego," that takes into account the actual constitution of the external world (16, p. 18, 19, p. 312). And "while the ego goes through its transformation from a *pleasure-ego* into a *reality-ego*, the sexual instincts undergo the changes that lead them from their original auto-erotism through the various intermediate phases to object-love in the service of procreation" (16, p. 19, 9, pp. 311–12).

Narcissism is a condition in which the libido, instead of being attached to objects, is attached to the ego as ego-libido or narcissistic libido. Freud made a theoretical distinction between egoism and narcissism, which he called "the libidinal complement of egoism" (16, p. 31), but in his practice, this distinction is not important. The libido of the new-born infant is in a state of "primary narcissism," as characterized by the delusion of "omnipotence of thought" (16, pp. 349–50). The new-born infant feels that it is the center of Creation and that the world (which, indeed, is not yet differentiated from the self) may be controlled by wishes (16, p. 875, 16, pp. 393–4). This state of delusional omnipotence is a survival from the intra-uterine state.

> . . . by being born we have made the step from an absolutely self-sufficient narcissism to the perception of a changing outer world and to the beginnings of the discovery of objects . . . we cannot endure the new state of things for long (and) periodically revert from it, in our sleep, to our former condition of absence of stimulation and avoidance of objects (12, p. 104).

Eventually the infant is forced to renounce his narcissism, to abandon the pleasure-principle. Yet, in all of us there remains a yearning for the intra-uterine (or suckling) state, and if the external world becomes too threatening, we withdraw our libido from objects and turn it back upon our egos. This transformation of object-libido into ego-libido is "secondary narcissism."

Freud interprets this conflict between narcissism or pleasure-principle and reality in terms of infantile libido demands and specific threatening situations—severity of birth, weaning traumas, toilet-training conflicts—or the "memory" of certain specific prehistoric threats. But occasionally Freud transcends the biological-utilitarian framework. Narcissism is seen as a basic attitude toward life, as a way of relating oneself to being. And the reality-principle then appears as the acknowledgement of finitude. The reality which shatters man's narcissism and dethrones the pleasure-principle is not this or that privation. It is categorical privation, privation imposed by the very structure of Existence itself—space, time, causality.

> . . . the power which has enforced this development upon mankind, and still to-day maintains its pressure in the same course, is known to us; it is, again, the frustration exacted by reality; or, if we give it its great name, it is *necessity*, the struggle for life, *ananké* (9, p. 310).

> (In the mind of the parents) the child shall have things better than his parents; he shall not be subject to the necessities which they have recognized as dominating life. Illness, death, renunciation of enjoyment, restrictions on his own will, are not to touch him; the laws of nature, like those of society, are to be abrogated in his favor; he is really to be the center and heart of creation. . . . (16, p. 48).
>
> . . . hate originally betokens the relation of the ego to the alien external world with its flux of stimuli (16, p. 79).
>
> The relation of hate to objects is older than that of love. It is derived from the primal repudiation by the narcissistic ego of the external world whence flows the stream of stimuli (16, p. 82).
>
> Neurosis and psychosis are both of them an expression of the rebellion of the *id* against the outer world, of its "pain," unwillingness to adapt itself to necessity—to ananké, or, if one prefers, of its incapacity to do so (13, p. 279).

In the scientific attitude toward life, there is

> no longer any room for man's omnipotence; he has acknowledged his smallness and has submitted to death as to all other natural necessities in a spirit of resignation (6, p. 375).

Freud also cites the mature writings of Leonardo da Vinci, which "contain the deep wisdom of his last years" and which "breathe the spirit of resignation of the man who subjects himself to the laws of nature and expects no alleviation from the kindness or grace of God" (13, p. 106).

In the passages quoted above and in his entire treatment of religion and the problem of happiness in *The Future of an Illusion* and *Civilization and Its Discontents*, Freud approaches the existentialists' description of the experiences of transitoriness, contingency, and alienation.

In existentialist thought, the experience of finitude depends upon an experience of something transcending finitude. In Tillich's words:

> Finitude . . . is the double-sided experience of the existing subject as bound to transitoriness and as transcending it in the awareness of the trans-temporal. The existing subject is aware both of its belonging to the infinite and of its being excluded from it and surrendered to finitude (26, p. 743).

In Freud, this awareness of a relationship to the trans-temporal and the infinite appears in the treatment of primary narcissism, of the Nirvana-principle, and, in a very rudimentary way, in his later concept of Eros.

Most of Freud's descriptions of narcissism, particularly his clinical descriptions, deal with the so-called "secondary narcissism." The secondary narcissism represents man's anxious (and unsuccessful) attempt to escape the threat of non-being revealed in the experience of finitude. This secondary narcissism involves an ego-ideal (superego), guilt, and perfectionistic strivings. Freud's account of "primary narcissism" is quite sketchy. In part, he seems merely to be describing the traits of the adult secondary narcissism and applying them to the infant. But primary narcissism is also a complete merging of the individual ego with the other. This element in primary narcissism is described in the opening pages of *Civilization and Its Discontents*, where Freud discusses the "oceanic feeling" allegedly at the base of religion. Herbert Marcuse (23) seeks to build on this a theory of creative narcissism, in which the individual is united with the world. But Freud himself regards primary narcissism as infantile and unauthentic. "Man cannot remain a child forever; he must venture at last into the hostile world" (4, p. 86). Man must give up the illusion of a loving God. He must in the spirit of resignation subject himself to *ananké* and expect "no alleviation from the kindness or grace of God." Here, again, Freud is closest to Sartre, whom Tillich calls in this connection the most radical and most consistent of the existentialists (25, pp. 149–50). For Sartre, the attempt of the free individual (the For-itself) to find security by uniting with the Cosmos (the In-itself) is futile and self-contradictory (24, pp. 198–99).

In Freud's final theory of the instincts, the Death-instincts seek to break down organic compounds into their inorganic components, while the Life-instincts seek to build living forms into more complex structures. Thus the Death-instinct appears primarily as a disintegrating force (an expression of non-being). However, in certain places, death is identified with peace, with release from tension. In fact, pleasure itself is absence of stimuli, and the primordial goal of life, lying at the root of the pleasure-principle itself, is the elimination of excitation (11, p. 71, 14, pp. 255–56, 18, p. 66). Thus, Life itself is something unwished for and "we are obliged to place all the results of organic development to the credit of external, disturbing and distracting influences" (11, p. 46, cf. 18, pp. 66–67). (Freud abandoned this extreme view in 1924 and held there were three principles: the primordial Nirvana-principle representing the death-instincts, the pleasure-principle representing the life-instincts, and the reality-principle representing the external world.) (14, p. 257).

Finally, one finds in some of Freud's later writings (20, 19, pp. 348–50) the Life-instincts identified with Plato's *Eros* or Empedocles' *philia* and regarded as a binding power which unites things together in larger totalities. (Edith Weigert has discussed this point (*Cf.* 27.)). Thus, in certain features of his treatment of primary narcissism, of the death-instincts, and of the life-instincts, we find a touch of mysticism—an awareness of a greatly sought after unity of the part and the whole. It is because man "remembers" this unitive state that he is able consciously to experience finitude, rather than simply to be finite. And this brings us to our last two concepts: anxiety and non-being.

In existentialist thought, anxiety is the awareness of non-being. Non-being is one of the most difficult existentialist concepts. It can only be presented symbolically, not described. But we may (inadequately) describe it as annihilation, destruction, loss of meaning, of purpose, of substance. Freud originally conceived anxiety as an automatic, biologically necessitated outcome of sexual repression. He later explicitly repudiated this conception and held that it is the anxiety that causes the repression (5, p. 50). Anxiety is a defense-reaction to a traumatic situation, a traumatic situation being one that the individual feels he cannot cope with. Freud believed that every individual in the course of his development encountered five great danger situations, each of which produced anxiety (5, pp. 96–105, 17, p. 116). The first is birth itself, and birth-anxiety is the prototype of all subsequent anxiety-reactions. The second is the absolute helplessness of the child in the external world. The third arises when the child becomes aware of its dependence upon the parents. The threat of loss of parental love, particularly separation from the mother (the woman who tends), becomes a source of anxiety. The fourth is castration anxiety, arising in the conflicts with the parents during the Oedipus phase (5, p. 108). And the fifth is super-ego anxiety, the super-ego being an internalization or introjection of external authority, particularly the parental authority operative in the Oedipus and castration complexes.

To existentialist analysis, these great danger situations are "reminders" of the threat of non-being. Birth, separation from the mother, castration are symbols of annihilation. Freud's explicit approach is the reverse of the existentialists'. Anxiety is a reaction to specific, physical threats. All generalized anxiety—anxiety of Fate, anxiety of death—is reducible to castration anxiety (5, p. 88). Even castration anxiety itself develops only because "castration becomes, as it were, imaginable through the daily experience of parting with the contents of the bowel and through the loss of the mother's breast which is experienced in weaning" (5, p. 87). It is only by virtue of the difficulties that Freud finds with his approach that he shows any similarity to the existentialists'.

One difficulty concerns birth-anxiety, which is supposed to be the prototypic experience of separation.

> The first anxiety experience, of the human being at least, is birth; and this means, objectively, separation from the mother.... It would be very satisfactory if anxiety as the symbol of a separation were to be repeated on the occasion of every subsequent separation, but unfortunately the applicability of the agreement I have just spoken of is discounted by the fact that, subjectively, birth is not experienced as a separation from the mother, since the mother, in the role of object, is entirely unknown to the narcissistic foetus (5, p. 89).

Here Freud virtually (but not explicitly) identifies the birth or separation anxiety with anxiety over loss of primary narcissism, as can be shown by repeating a passage already cited:

> ...by being born we have made the step from an absolutely self-sufficient narcissism to the perception of a changing outer world and to the beginnings of the discovery of objects.... (12, p. 104)

In existentialist terms, the separation is not from the mother as an object. It is the disruption of the unitive state of ego and world (finite-infinite); it is the transition from essential being (and the oceanic feeling) to existence as "standing out from" (*ex-sistere*). Freud, of course, does not go this far; and his agreement with the existentialists shows up only in his admission that there is no "realistic" basis (*i.e.*, in terms of the mother as perceived object) for birth-anxiety.

Another negative agreement comes from Freud's failure to find any correlation between severity of environmental threat and subjective-reaction—the same problem that originally plagued him with respect to sexual traumata. To save his reductionistic hypothesis, Freud had to have recourse to "phylogenetic memories." Finally, he could find no reason why childhood anxiety-reactions to danger-situations were repeated in adults.

> Why are not all neuroses merely episodes in the individual's development which becomes a closed chapter when the next stage of development is reached? Whence comes the element of permanency in these reactions to danger? Whence springs the preference over all other affects which the affect of anxiety seems to enjoy in alone evoking actions which we distinguish from others as abnormal and which in their inexpediency obstruct the stream of life? In other words, we find ourselves abruptly confronted again by the oft-repeated riddle: What is the source of neurosis, what is its ultimate, its specific, underlying principle? After decades of analytic effort this problem rises up before us, as untouched as at the beginning? (15, p. 120)

It seems to us that Freud, in fact, did better than he knew, and that the elements for a solution to the problem of anxiety are present in Freud's thought and need only be rendered explicit and freed from the reductionistic framework in which they are embedded. In two places Freud virtually states that the adult uses the ideational content of his early experiences to formulate or symbolize his "encounter with nothingness." In his analysis of religion, Freud states that the idea of God represents a utilization by the adult of childhood father-images for the purpose of representing the adult's experience of the threatening outer world (4, pp. 41–2, 17, pp. 208–9). And in his treatment of castration-anxiety, Freud states that the castration complex derives from the high narcissistic cathexis of the penis, rather than from its intrinsic biological value. The penis may be a symbol of productivity and masculinity, may appear as *pars pro tota* for "the man" or the species. This symbol-function of the penis, along with the phenomenon of penis-envy, suggests that the penis is a symbol of omnipotence, of exemption from the threat of non-being. Thus in these two points, Freud approaches the existentialist concept of anxiety; but for the most part, Freud in his explicit analysis of anxiety remains within the framework of his reductionist, anti-teleological approach.

It has been said many times, by neo-Freudians and other critics, that Freud was a product of his times and that his ideas are bound to an obsolete mechanistic approach to human nature. We hope the above analysis has shown that Freud was more than a product of his times, that by virtue of his creative genius and his radical openness to experience he was able to transcend his inherited mechanistic framework, and that not only his empirical observations but also his metapsychological concepts are quite compatible with the current existentialist approach to man

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PSYCHOLOGIC CHANGES INDUCED BY RESERPINE THERAPY ON A GROUP OF SEVERELY DISTURBED PSYCHOTICS

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The widespread use of tranquilizing agents in the treatment of psychiatric disorders has emphasized the need for interdisciplinary research studies of the psychologic effects of these drugs. Accumulated research is already voluminous and there are no signs of diminishing popular or scientific interest. In this study 20 psychiatrists, 3 psychologists, and 25 nurses and attendants at St. Elizabeths Hospital took part in evaluating the effect of reserpine[2] therapy on severely disturbed psychotic patients who had not responded to other forms of treatment. This group of patients was used for a parallel psychiatric study by Hoffman and Konchegul (3) who reported in terms of hours that patients spent in seclusion, in need for restraint, and in general ward behavior.

The measures selected include the Multidimensional Scale for Rating Psychiatric Patients (MSRPP) (6), an abbreviated Wechsler Bellevue Intelligence Scale, and Rorschach Ink Blots which were evaluated according to Klopfer's Rorschach Prognostic Rating Scale (RPRS) (4).

SUBJECTS

Eighty-eight of the most excited, combative, hostile, and restless patients to be found in four major administrative services housing 2400 patients were selected for study. Their ages ranged from 18 to 60. Each service chief was asked to select either 20 or 24 of the most disturbed patients regardless of diagnostic classification and to indicate the upper and lower quartiles in degree of disturbance. These patients were scattered over several disturbed wards in two of the services and in the other two services resided on one ward with about 25 highly disturbed patients.

PROCEDURE

The research design was essentially the usual experimental-control group type of study but repeated after a reversal of treatment at the midpoint.

All patients in the sample were divided into matched pairs on the basis of age, length of hospitalization, diagnosis, and severity of illness. One of each pair was assigned to Group I or Group II as determined by a table of random numbers. The results of matching are shown in Table I.

One-fourth of the 88 patients were above 45 years of age and 7 were 25 or younger. The length of time in the hospital ranged from 7 months to 22 years with 11 patients being hospitalized for at least 10 years and 65 being hospitalized for at least 2 years. Of the 88 patients selected, 58 were Negro and 30 were white. Sixty-four of the group were male.

Chronologically, the research design developed as follows:

1. Both Group I and Group II were given the initial evaluation with all measures during the week preceding the start of therapy.
2. Group I received reserpine for 7 weeks and Group II received a placebo.
3. During the seventh week both groups were given a second evaluation to determine the effects of treatment.

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[1] Bureau of Naval Personnel. Study conducted while the author was associated with St. Elizabeths Hospital, Washington, D. C. The cooperation of the staff of this institution in gathering the data and especially the assistance of Dr. Albert D. Annis, St. Elizabeths Psychology Branch, in the preparation of this paper is gratefully acknowledged.

[2] Trade name Serpasil by Ciba Pharmaceutical Products, Summit, N. J., the supplier of the drugs and the placebo used in this study.

TABLE 1

Distribution of Patients in Group I and Group II According to the Matching Variables

	Avg. Age	Avg. mo. in Hospital	Diagnosis	Degree Disturbed
Group I	37.2	55.3	35 Schiz[1]	12 most
N-44			9 other[2]	11 least
Group II	37.3	56.1	38 Schiz[3]	10 most
N-44			6 other[4]	11 least

[1] Includes 16 catatonic, 5 catatonic-paranoid, 1 hebephrenic, 1 hebephrenic-catatonic, 1 hebephrenic, 9 paranoid, 2 schizoaffective, and 1 undifferentiated.

[2] Includes 3 chronic brain syndrome, 1 paretic, 1 depressive reaction, 1 involutional, 1 psychopathic personality, 1 feeble-minded, and 1 psychosis undifferentiated.

[3] Includes 15 catatonic, 3 catatonic-paranoid, 4 hebephrenic, 1 hebephrenic-catatonic, 1 hebephrenic-paranoid, 11 paranoid, 1 schizoaffective, and 1 undifferentiated.

[4] Includes 4 chronic brain syndrome, 1 manic depressive, and a sociopathic personality.

4. At the end of the seventh week, the treatments were reversed without any apparent interruption so that the group which received the placebo was now given reserpine and *vice versa*.

5. A third evaluation was made with all measures during the fourteenth week of treatment.

No one involved in the experiment was told what type of medication any patient received. As can be expected, many psychiatrists felt they could guess which patients were receiving the drug, but these guesses were frequently in error. Only the study coordinator of the hospital staff knew the exact identity of "Medication A" and "Medication B" which were distributed to the wards. The above labels could have meant reserpine in one ward and placebo in another. The placebo could not be distinguished from the reserpine in taste, smell, or appearance.

The physician in charge recommended the following dosages with instructions that amounts be individualized according to the patients:

"Give 2 mg. by mouth daily unless side effects appear in which case reduce the dose to ½ mg. per day. Give an additional 5 mg. intramuscularly on the third or fourth day. Repeat this for two or three days. If there is no marked improvement, increase to 10 mg. per day I.M. daily until desired tranquilizing effect is achieved. Thereafter continue only on oral medication with occasional "booster" doses of 5 mg. I.M. P.R.N."

MEASURES

MULTIDIMENSIONAL SCALE FOR RATING PSYCHIATRIC PATIENTS

This psychiatric rating scale was designed for use in VA hospitals to evaluate treatment programs. It consists of 62 brief scales which rate the patient's motor activity, stream of talk, physical complaints, emotional reactions, orientation, delusions, hallucinations, and persistent thoughts and impulses. Forty items in this scale are rated by psychiatrists after a 45-minute interview with the patient. Twenty-two items deal with ward behavior and are filled in by the nurse or attendant most familiar with patient's ward habits. This rating scale may be analyzed in terms of factors which are relatively independent dimensions of behavior, and patterns which represent a more general syndrome of behavior. In addition, an overall morbidity score may be determined which is based on the patient's deviation from an empirically determined norm for each of the 11 factors.

WECHSLER BELLEVUE INTELLIGENCE SCALE

This test was intended to determine the subject's ability and willingness to make creditable responses to certain fixed intellectual tasks. The distractability of these disturbed patients made it impossible for many of them to remain cooperative over a long period of time. Thus, an abbreviated form consisting of Information, Block Design, Similarities, Digit Span and Vocabulary subtests of Form I was chosen.

RORSCHACH INK BLOT TEST

An individual Rorschach was administered according to Klopfer's Prognostic Rating Scale (RPRS) procedure. This scale attempts to predict the response of patients to psychotherapy by measuring what Klopfer terms "ego strength" as reflected in the patient's use of shading, color, movement, and the accuracy of Rorschach associations. In order to be included in the Rorschach data, a patient was required to give at least one scorable response during each of his three Rorschach interviews. This reduced the number of cases to 27 in the Rorschach data for each of the two groups. The Rorschach protocols were scored by an experienced clinical psychologist on the hospital staff who had no knowledge as to the type of treatment the patient received.

RESULTS

Although test-retest measures would be helpful in tracing each group throughout the study, the data presented will stress the comparison of the control and experimental groups. Significances were determined by a "t" test of differences between differences.

MSRPP MORBIDITY SCORE

This score is based on the deviation of the 11-factor scores from the normal score for that factor. Thus, a high score would imply high morbidity and a low score more normal behavior. Results are shown in Table 2.

The morbidity score of the average patient in this study exceeded 90 per cent of the scores in Lorr's normative psychiatric population. Thus, the nature of this sample would tend to make positive results easier to obtain than with a less disturbed group since the amount of change is to some extent dependent on initial morbidity.

The relatively greater effectiveness of reserpine therapy in reducing morbidity during the first 7 weeks is shown not only by the comparison of averages, but also by examining the manner in which individual cases were affected. After the first 7 weeks, 86 per cent of the patients initially

TABLE 2

Mean MSRPP morbidity scores for indicated periods of measurement and medication

First 7-Week Period

Group	Medication	Pretest	Second measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Reserpine	51.15	36.18	Lower morbidity	−14.97	2.72	.001
II	Placebo	48.84	48.13	Lower morbidity	−0.71	2.52	n. s.
I minus II					14.26	2.34	.001

Second 7-Week Period

Group	Medication	Second measure	Third measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Placebo	36.18	38.86	Greater morbidity	+2.68	1.92	n. s.
II	Reserpine	48.13	45.09	Lower morbidity	−3.04	2.58	n. s.
I minus II					5.72	3.61	n. s.

on reserpine showed a lower morbidity ($P < .01$). Only 48 per cent of those receiving reserpine after 7 weeks of placebo showed any decrease of morbidity on this rating scale.

MSRPP FACTORS

Each factor score is based on the patient's rating on a three to five step continuum on four to seven scale items which are related to certain dimensions of behavior. During the first 7-week period, it was indicated that patients on reserpine became more compliant, submissive, and less withdrawn. They also exhibited less paranoid projection, were better organized conceptually, showed less motor disturbance than those in the placebo group. These trends were shown by changes in the factors of Submissiveness-Belligerence ($P < .001$), withdrawal ($P < .001$), Paranoid Projection ($P < .005$), Compliance-Resistiveness ($P < .02$), Conceptual Disorganization ($P < .025$), and Motor Disturbances ($P < .05$). The factors of Depressive *versus* Manic Activity level, Melancholy Agitation, Perceptual Distortion, and Grandiose Expansion, did not reach the .05 level of significance. During the second 7 weeks, the reserpine group reacted by making changes in the same direction as the reserpine group of the first 7 weeks, but in no instance did these changes reach the .05 level of significance when compared with the placebo group.

PATTERN SCORES

Pattern scores reflect the total number of times the patients' ratings agree with those of a given pattern type. Three patterns, Manic Excitement, Panicky Agitation, and Mournful Depression are defined by Lorr as being typical of the affective psychoses; and the other three patterns, Resistive Isolation, Psychotic Reorganization, and Schizophrenic Disorganization are more common to schizophrenics. A significant difference between the reserpine and placebo group for the first 7 weeks occurred only in the Schizophrenic Disorganization pattern ($P < .001$) where the reserpine group showed a great improvement characterized by better verbal communication.

During the second 7-week period, the changes in the Schizophrenic Disorganization ($P < .05$) and Panicky Agitation ($P < .05$) patterns suggest that the patients tend to become more communicative, but also more dysphoric. The changes in the other patterns did not approach the .05 level of significance for either 7-week period.

WECHSLER BELLEVUE INTELLIGENCE SCALE

Changes in the Wechsler Bellevue total weighted scores during the study are shown in Table 3.

Uniform and sizeable gains by the reserpine group when compared to the placebo group were shown more consistently on the Wechsler-Bellevue Scale than on any other measure of the study. The groups not only performed significantly better on most subtests after reserpine, but also were able to show comparable gains for both 7-week periods of medication.

When compared with the control group, the Vocabulary subtest reflected the largest gain ($P < .005$ first 7 weeks and $P < .001$ second 7 weeks) in weighted scores after reserpine therapy. Similarities and Block Designs made the smallest gains ($P < .10$ to $P < .35$). This suggests that greater improvement can be expected in communication than in the problem-solving functions.

RORSCHACH (RPRS) RESUTS

In this scoring of the Rorschach, the patient's movement, shading, color, and form ratings were added to give a measure of adjustment potential. Results are shown in Table 4. Only 54 of the 88 patients (27 in each group) were willing and able to give scorable responses and are included in the results. The two subgroups used in the Rorschach results did not show any significant difference in age, length of hospitalization or in the initial measures.

TABLE 3

Mean total weighted scores for abbreviated Wechsler Bellevue Scale for indicated periods and medications

First 7-Week Period

Group	Medication	Pretest	Second measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Reserpine	17.30	25.96	Better performance	+8.66	1.84	.001
II	Placebo	20.40	21.26	Better performance	+0.86	1.62	n. s.
I minus II					7.80	2.45	.005

Second 7-Week Period

Group	Medication	Second measure	Third measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Placebo	25.96	22.97	Poorer performance	−2.99	1.43	.05
II	Reserpine	21.26	26.12	Better performance	+4.86	1.62	.005
I minus II					7.85	2.44	.005

TABLE 4

Mean total RPRS scores for indicated medications and periods

First 7-Week Period

Group	Medication	Pretest	Second measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Reserpine	−4.13	−2.78	Better prognosis	+1.35	0.446	.005
II	Placebo	−3.28	−2.71	Better prognosis	+0.57	0.351	n. s.
I minus II					0.78	0.671	n. s.

Second 7-Week Period

Group	Medication	Second measure	Third measure	Direction of change	Diff.	S.E.$_{\text{Diff.}}$	P
I	Placebo	−2.78	−2.81	Poorer prognosis	−0.03	0.381	n. s.
II	Reserpine	−2.71	−2.42	Better prognosis	+0.29	0.298	n. s.
I minus II					0.32	0.572	n. s.

The average initial RPRS score of the subjects of this study would fall into a category which Klopfer describes as "a difficult case that may be helped somewhat, but is generally a poor treatment prospect." The average score remained in the above category after reserpine treatment in spite of a small advance in the direction of a better prognosis. Whatever change in scores was obtained in the total RPRS score for both groups can be almost entirely accounted for by the changes in the color component. As in the other measures, it was shown that the amount of gain was greater for the group which had reserpine during the first 7-week period than the second.

DISCUSSION

All three measures show that the group which received reserpine initially benefitted more than the group which had received reserpine only after placebo treatment. This difference in results was not anticipated and the experiment was not designed to give an answer to this problem. A third group of patients matched with the other two and receiving only placebo for the full 14 weeks would have been a valuable addition. In the absence of experimental findings it can only be assumed that certain subtle psychologic factors such as the greater initial enthusiasm of the patients and hospital personnel, and the sudden change in the social climate of the wards upon changing to a medication routine may have combined more advantageously with the drug effects in the case of group which received the reserpine before the placebo. It is also possible that many of the group which received the placebo before the reserpine became disappointed and reacted by becoming more resistant to showing any behavioral improvement. While no adequate explanation for the unequal effectiveness of reserpine on the two groups is possible, it seems plausible to assume that this difference is due to psychologic rather than physiologic factors. The temporary nature of reserpine therapy was indicated by the tendency of almost all measures to revert to the direction of their prereserpine status when the drug was withdrawn.

SUMMARY AND CONCLUSIONS

Eighty-eight psychiatric patients, nearly all schizophrenic and all considered to be among the most severely disturbed, were divided into matched pairs to form an experimental (reserpine) and a control group (placebo). A preliminary evaluation was made using Lorr's Multidimensional Scale for Rating Psychiatric Patients, an abbreviated Wechsler Bellevue Intelligence Scale, and individual Rorschach. The experimental group then received reserpine and the control group placebo for a period of 7 weeks. Then a second evaluation was made. The medications were reversed and a third measure was made 7 weeks after the switch in medications.

Results show that the average patient of this study becomes more compliant, submissive, communicative, and outgoing, but perhaps somewhat more dysphoric after reserpine therapy. Intellectual functioning as shown by Wechsler-Bellevue performance is improved, but there seems to be no significant improvement in potential ego strength as shown by the application of Klopfer's Prognostic Rating Scale to the Rorschach.

A decrease in pathology was suggested by the three measures which were employed. The beneficial effects of reserpine were more pronounced for the group which had received reserpine initially than for the group which had received reserpine after a period of placebo treatment. It was further suggested by these measures that patients changed from reserpine to placebo do not maintain the gains made on the drug.

The relatively greater gains for the reserpine group during the first 7-week period suggest the importance of nondrug factors which must be taken into account in any subsequent research.

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ELECTRIC SHOCK CASUALTIES

NAOMI RASKIN, M.D.[1]

Although with the advent of the tranquilizing drugs the number of electric shock treatments has decreased, EST is still a treatment of choice in cases of severe depression. It is considered a safe method of treatment, for the number of deaths reportedly caused directly or indirectly by EST is small, while treatments have risen to very large numbers indeed. Kolb and Vogel (19) have estimated fatalities due to EST as 0.5 per one thousand cases, Impastato and Almansi (15) as 0.8 per one thousand cases.

Kaldeck and his co-workers (17) expressed the opinion that physical risks of EST are minimal. Kalinowsky and Hoch (18) state that fatalities are extremely rare in EST, and express the opinion that the connection between death and EST is doubtful in some of the cases so reported. On the other hand Maclay (23) warns not to take risks lightly merely because the patient is mentally abnormal.

Pulmonary and cardiac complications have been considered the main cause of death, the post-mortem cardiac pathologic findings being predominantly coronary sclerosis with recent or old myocardial infarcts. The patients who died following EST were found to have been suffering from severe hypertension, coronary disease, general and cerebral arteriosclerosis, nephritis or tuberculosis, prior to EST (7, 16, 26, 29, 32, 9, 24, 33, 13, 22, 20, 12), but findings at autopsy did not always explain clearly the mechanism of death. Cases have been reported in which the cause of death remained obscure, for clinical and autopsy findings were minimal or completely lacking. Death in these cases have been attributed to cardiac reactions following over-activity of the vagus in about 30 per cent of cases or to cardiac disturbances from other extra-cardiac causes (14).

Vagal reaction manifests itself by severe bradycardia immediately after the treatment. EKG changes have been recorded during or after treatment, as well as the changes in respiration (1, 2, 3, 21, 4, 5).

Seven deaths attributed to EST occurred at Boston State Hospital during the period of 1942–1956 inclusive. A total of 82,046 treatments were given to 6,535 patients with the ratio of one death per 11.721 treatments, or one death per 933.5 patients. These mortality figures are slightly higher than those reported in the literature, perhaps because old age and physical pathology *per se* were not considered a contraindication to treatment since EST is known to benefit old depressed patients (25, 10, 34, 30, 11). The findings in 112 patients aged from 65–83 with an average age of 71.3 who were treated at this hospital were reported by Ehrenberg and Gullingsrud (8). The third patient of this series is one of their 112 cases.

Case 1. This was the first case of death after EST which occurred in 1942.[2] The patient was a 23 year old male, well developed and nourished, who had previously had metrazol and insulin treatments without benefit. He was given a series of 24 daily EST without improvement and two months later a second series was begun. He had seven EST without complications. On his eighth treatment, he received 800 milliamperes for 0.3 of a second, and a convulsion was obtained. He became restless in the evening, went to the bathroom frequently. He became dyspneic at midnight, had pulmonary edema, the pulse of

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[1] Boston State Hospital, Boston, Massachusetts.

[2] This case is one of three reported by Jetter (16).

120 and respiration of 52 per minute. He collapsed and died about 15 hours after the EST. Autopsy showed serous fluid in the pleural cavities and in the abdominal cavity, acute non-suppurative glomerulonephritis, acute focal non-suppurative myocarditis, acute pulmonary edema, peripheral edema of the ankles and sacrum, hydrothorax and ascitis; passive hyperemia of visceral organs, including the brain. Death resulted from rapidly progressive heart failure and peripheral collapse. Circulatory failure is not an uncommon complication of acute glomerulo-nephritis. EST was only a complicating factor introducing further strain on the already overtaxed heart.

Case 2. This patient[3] was a 51 year old male with severe hypertension; 240/160, hypertensive heart disease, general and cerebral arteriosclerosis, and presented a picture of severe depression. Heart was slightly enlarged. EKG showed borderline T2. X-ray showed prominence of the aortic knob. Eyeground examination showed a-v nicking. There was right hemiparesis and positive Babinski, tongue deviated to the left. The patient had had at least one grand mal seizure. Laboratory findings: Blood-count within normal limits, NPN, 42 mgs/100 cc. of blood. Cerebrospinal fluid: I.P.-160, F.P.-120, colorless, Pandy-1+, total protein 65 mgs. per 100 cc. Urine negative. The dangers involved in EST were well understood, but the patient was in such need of treatment for his depression that the risk was considered worth taking. He had six treatments and his depression was noticeably relieved. After the seventh treatment he vomited, became restless and unsteady on his feet. Both eyes deviated to the left and slightly upward. There was no respiratory difficulty. He died three hours later. The autopsy showed extensive damage caused by hypertensive disease, large heavy congested liver with fatty degeneration, weighing 1800 gms., and widespread severe cerebral arteriosclerosis, encephalopathy, a vascular cerebral lesion, coronary sclerosis, nephrosclerosis, evidence of increased adrenal and pituitary activity, and a right spontaneous cerebellar hemmorrhage. The hemorrhage was due to the rupture of the right cerebellar artery and had destroyed the nucleus dentatus, brachium pontis, anterior and medial cerebellar lobes and most of the lower cerebellar lobe. Severe arteriosclerotic changes of all cerebral arteries and vascular lesions in the head of the right caudate nucleus obviously antedated the EST. The cerebellar hemorrhage which followed the last (seventh) treatment could conceivably have taken place even if EST were not given, judging by the severity of arteriosclerotic involvement. The remarkable point is that the patient with a very severe cardio-vascular disease and multiple cerebrovascular lesions withstood the stress of six electric shocks. It seems that the death of this patient could not be ascribed entirely to EST, the latter being a contributing factor only.

Case 3. This 73 year old alcoholic of Korsakoff's type, was confused, excited, deluded, argumentative, flighty and irrational. He appeared to be well developed and well nourished. Blood pressure 138/80. Hinton negative. Tongue deviated slightly to the left. Slight swaying in Romberg position was present. Babinski was negative. Laboratory findings were within normal limits except for a high eosinophilic count. X-ray showed pronounced senile osteoporosis of the bones of the legs, extensive calcification of the popliteal, posterior tibial and peroneal arteries, and a tortuous aorta. The heart was not enlarged. He was given a series of 30 EST, became quiet and cooperative, but the improvement did not last and he was given another series of 21 EST. He died after the twenty-first treatment. The cause of death was coronary occlusion. The autopsy showed general and cerebral arteriosclerosis, coronary sclerosis with partial occlusion, old healed myocardial infarcts, increase in subarachnoid fluid, hyperemia of the lungs, liver, spleen and kidneys, moderate nephrosclerosis and benign hypertrophy of the prostate. Liver was large and fatty. Brain, slightly smaller the average, weighed 1340 gms. The vessels of the base of the brain were calcified, especially the basilar artery which was wide, tortuous and shining white. The left vertebral artery was rudimentary, the right vertebral was large and wide, almost the same diameter as the basilar artery. On coronal section of the cerebral hemispheres there was a slight enlargement of the lateral ventricles, more evident in the anterior horns than elsewhere. The third ventricle was also unusually wide and the aqueduct of Sylvius seemed larger than normal. Mammillary bodies showed no lesions.

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[3] Previously reported in greater detail (27).

The impression was that of slight brain atrophy and of healed Wernicke disease. The brain changes, atrophy and arteriosclerosis, obviously antedated the EST.

Case 4. This 64 year old white woman was admitted to Boston State Hospital, August, 1917, at the age of 27 with the diagnosis of manic-depressive psychosis. Throughout her stay she was overactive, angry, manneristic, screaming, and actively hallucinating. In 1949 lobotomy was considered but the family refused to sign the permit. The last physical examination showed an obese woman with blood pressure of 122/80. On the second of June, 1954 she had her first and, as it turned out, her last EST. One minute after the shock she was cyanotic, not breathing. Artificial respiration, clearing of the airways, oxygen were of no avail. She was pronounced dead 45 minutes later. Autopsy showed coronary sclerosis with occlusion, fatty degeneration of the heart which was very soft and flabby, bilateral pulmonary congestion and blood in bronchi, cholelithiasis, and a large fatty liver (2000 gms.), pale brain, weighing 1050 gms. and the cyst of the right cerebellar hemisphere. The microscopical examination revealed fatty degeneration of liver of extreme degree. This case seems to confirm the opinion that obese people are poor risks for any mechanical or surgical intervention.

Case 5. This 59 year old white housewife was admitted May 30th, 1955, with the diagnosis of involutional psychosis after an attempted suicide. She had a series of 11 EST at another hospital prior to admission without much improvement. She was greatly depressed, was openly wishing for death, insisted that has had "cancer of the bowels" and rather than die slowly wanted to commit suicide "to finish it all." She bore marks of a suicidal attempt—several cuts and lacerations of neck and wrists. She had colitis two years prior to admission, menopause in 1949, a gall bladder operation in 1948, a hemorrhoidectomy in 1949, and exploratory laparotomy in 1954. Physical examination of heart and lungs, X-ray of heart and lungs, blood count and EKG were normal. Blood pressure 130/80. Fasting blood sugar was 100 mgs. and NPN 40 mgs. per 100 cc. of blood, sedimentation rate 34. She was given atropine gr. 1/100 and all food was withheld. EST was given June 6th, 1955. Double combined Reiter was used. The patient was in the recovery room and seemed to be recovering normally when suddenly she began to turn cyanotic. Respiration and pulse stopped. A respirator was used and adrenaline given intracordially, but there was no response. Autopsy showed heart weighing 260 gms. The descending anterior branch of the left coronary had many yellow patches causing some irregular narrowings of the lumen. It was thought that the patient had acute myocardial insufficiency. Mycroscopical examination showed that she had also an acute exacerbation of chronic pyelonephritis.

Case 6. This 31 year old single white women[4] had been admitted to Boston State Hospital at the age of 20 because of her peculiar behavior, apprehension, anxiety, disheveled looks, filthy clothes and rambling talk. She had insulin therapy in 1940 without much seeming benefit. Because of loss of weight, pallor and anemia, X-rays of the chest were repeatedly taken in 1941 and 1942 and found negative. In 1945 and 1946 she had numerous physical and laboratory examinations because of severe secondary anemia. She was put on iron and liver extract, but her blood count remained low. X-rays of the lungs showed no evidence of pulmonary tuberculosis. G.I. series were not done because the patient would not cooperate. In 1951 it was decided to try EST. This treatment had been considered earlier, but was postponed because of suspicion of organic lesion. Because of her violent behavior, negative chest X-rays and negative EKG, the patient was started on a course of EST. She showed no improvement. Six months later after her thirty-fourth treatment, she had a sudden abdominal pain and vomiting. Her temperature went up. She had tenderness in the right upper quadrant, fever, chills and fluid in the left pleural cavity. In spite of the treatment she deteriorated and died 35 days after the last EST. Autopsy showed negative blood vessels including the coronary artery and aorta. The left lung showed a fast growing highly malignant epithelial tumor with metastases into liver and lymph-nodes. Duodenum had a perforated peptic ulcer. The base of the ulcer was adherent to the head of the pancreas. Brain was pale and edematous. This case is of additional interest because of the theory of the neurogenic origin and the life history of duodenal ulcer. Rokitansky expressed the opinion that duodenal ulcers are of cerebral origin. Cushing and other investigators elaborated this theory (6). Selye (31) stated that treatment with large doses of ACTH and cortison tends to aggravate the course of peptic ulcer and may even produce such lesions in previously healthy individuals. In shock there is endogenous ACTH discharge. That severe emotional stress may produce peptic ulcer has been demonstrated in the last war, when victims of air-raids developed peptic ulcers. This has also been seen in cases of severe burns. Emotional episodes of various nature tend to aggravate the ulcer, and relief of emotional states influences favorably its course. Barbiturates encourage healing by decreasing neurogenic and psychological stress stimulation. In the patient subject to a stress-producting action of EST there is an increase of ACTH as was revealed by the study of 17 ketosteroids, lymphocytic and eosinophilic changes. In our patient who did not benefit by EST, whose anxieties remained unchanged, but in whom the EST had increased the production of pituitary hormones, the factors conducive to formation of, or aggravation of the preexisting peptic ulcer, were increased in intensity and led to the preforation of the ulcer. The post-mortem findings of the tumor of the lung came as a surprise, as there was no clinical or radiological evidence of it before the treatment, and raised the question of the relationship between development and EST. We should venture the suggestion that EST may increase the production of other hormones as well as of ACTH, which may have a stimulating effect on the growth of malignant cells.

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[4] Previously reported in greater detail (28).

Case 7. This 49 year old white married man had been a patient in this hospital on and off for several years. He had two admissions to a general hospital, in 1948 with delirium tremens and in 1952 with alcoholic hallucinosis. He had periods of depression for many years. He was admitted to Boston State Hospital in July, 1952 because of withdrawal, mutism, ideas of persecution, with especially torturing idea that some one was going to kill him. Physical examination showed an obese, slovenly individual. Liver was three finger breadths below the costal margin and tender on palpation. Blood pressure 148/92, pulse 64. X-ray of the chest: Lungs clear, heart moderately enlarged, aorta slightly tortuous. Laboratory reports: Blood sugar 139 mgs. per 100 cc. of blood. NPN 48 mgs. per 100 cc. of blood. BSP test: the dye was not excreted in 30 minutes. Hematocrit 49. Red blood count 5.220.000. White blood count 5.400 with normal differential formula. Icteric index 7. Hinton negative. Mental examination: Not talking, not answering any questions, catatonic, and a feeding problem. He had six EST in 1949 with fleeting improvement, and 8 EST in 1954. On May 4th, 1955 he was given EST but did not convulse. He was given another treatment with Molac, and again did not convulse. A few minutes after being transferred to the recovery room he stopped breathing. The patient was given artificial respiration for 20 minutes, one ampule of coramine and one ampule of ephedrine intramuscularly and one ampule of aminophillin intra-cordially. Autopsy showed an obese white male. Blood vessels showed no atherosclerosis. Heart was enlarged, weighed 445 gms. Lungs were negative. Liver was large, weighed 2200 gms, was nodular and cirrhotic. Spleen was large, 300 gms. Kidneys weighed 200 gms. each. Brain weighed 1360 gms. Gyri were of small size. Cerebral vessles were negative. Sections revealed no infarct, hemorrhage, or Wernicke's disease. All cerebral vessels were of small caliber, thin-walled and delicate. Microscopical examination showed portal cirrhosis of the so-called Laennec's lobular type. Fatty degeneration of hepatic cells was so pronounced that some lobules were practically devoid of functioning cells.

Unexpected deaths in people with fatty liver are not uncommon. It seems that patients with fatty liver cannot stand an added strain and stress of EST.

DISCUSSION

In compiling the causes of death it is seen that four patients out of seven had liver involvement, and five had vascular lesions, either coronary or cerebral or both. One of these five had also a cerebellar hemorrhage, one a severe fatty degeneration of the liver and a cyst of the cerebellum, another a chronic and acute pyelo-nephritis. The sixth patient had a perforated duodenal ulcer and a cancer of the lung with metastases into the liver, and the seventh patient had alcoholic cirrhosis of the liver with severe fatty degeneration of hepatic cells. The time between the treatment and death was from one minute to 35 days. Death occurred after the first treatment in one patient; all others had had previous treatments without untoward effects. No curare or its derivatives were used in any of these cases. A calculated risk was involved in all. It should be added that within this period two patients scheduled for EST developed fatal coronary attacks. Had they lived 24 hours longer they would have been treated with EST which undoubtedly would have been considered the cause of death. These casualties emphasize the difficulty of the decision the physician must make when the patient in need of prompt mental treatment is also suffering from a severe systemic disease.

The impression gained from this survey was: 1) That obese people with fatty liver present a very serious risk, perhaps the most serious of all. Other types of tranquilizing treatment should be used, except Thorazine, which is not tolerated well by patients with hepatic involvement. 2) That careful physical examination should be done not only before but also during and after the period of treatment. The sixth cause in the reported series illustrates this point; the patient with negative lung x-rays before the treatment died of perforated duodenal ulcer and cancer of the lung six months later. It seems that in some cases the physical examination repeated after the end of the treatment may well prevent these complications however infrequent they may be.

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THE LIFE AND ACTIVITY OF I. M. SECHENOV

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In one of his early pronouncements on conditioned reflexes, speaking of the origin of his investigations, I. P. Pavlov refers to the "father of Russian physiology," I. M. Sechenov. He says: "As to the point of departure of our studies I consider, as such, the end of 1863, the date of appearance of Sechenov's famous essay 'Reflexes of the Brain'."

Since that time the two names—Sechenov and Pavlov—have often been linked together, and there are indeed many common features in the scientific endeavors and the personalities of these two investigators. At the same time, there are striking and profound differences in their essential character traits, which to a very great extent account for the different destinies of their teachings and the different course of their personal lives. Suffice it to say that while Pavlov's name and the basic concept of the conditioned reflex are now familiar to every college student, Sechenov's name is known only to very few specialists, and, while Pavlov's activity was an uninterrupted chain of scientific and personal successes, Sechenov's was a tormented life in which brilliant success and recognition alternated with bitter personal disappointments and with lack of understanding on the part of his contemporaries for his most important scientific achievements.

SECHENOV'S CHILDHOOD AND EARLY EDUCATION. HIS STUDIES AT THE MILITARY ENGINEERING SCHOOL. UNIVERSITY CURRICULUM AND GRADUATION. POSTGRADUATE STUDIES IN BERLIN, VIENNA, AND HEIDELBERG. (1829–1860)

Ivan Mikhailovich Sechenov was born on August 1, 1829, in a small township called Teply Stan, in the province of Simbirsk, situated at the central portion of the river Volga. His father, a retired army officer, belonged to the provincial gentry, but was quite indifferent to the interests, privileges and traditions of his caste. He married a simple but very intelligent and pretty peasant girl, whom, before marriage, he had sent to a convent to learn to read, to write and to do needlework.

The young Sechenov received his first education at home. The parish priest taught him arithmetic, Russian and Latin, and he picked up a good knowledge of French and German from his sisters for whom a governess had been hired to teach them foreign languages, as was the custom of the time.[1]

At the age of 14 Sechenov was taken to St. Petersburg where, after passing the prescribed examinations, he entered the Military Engineering School. Of the subjects taught in the school, Sechenov was especially interested in mathematics, physics and chemistry, paying much less attention to the study of military engineering.

Sechenov did not complete his studies as originally planned. He soon became very unpopular with his teachers who disliked his independent, sometimes mischievous character. The first serious incident occurred when Sechenov permitted himself to play a trick on one of his teachers. This teacher was known for his fear of his superiors whom he always tried to please in every possible way. He was especially afraid of the official patron of the Military Engineering School, the Grand Duke Mikhail Pavlovich, who kept close watch on its activities. When the Grand Duke visited the school this teacher turned pale and literally trembled with fear. Sechenov decided to frighten the hapless teacher. His fellow students put a mask on his head, one of the pupils suddenly opened the door of the classroom where the teacher was giving his lesson and solemnly announced: "The Grand Duke is coming." At these words the masked Schenov entered the room to the delight of his classmates who burst into an uproar of laughter. However, the rejoicing did not last long. At the noise the officer on duty rushed into the class and Sechenov was severely punished. He himself relates this episode as follows. "He (the officer) tore the mask off my head and marched God's servant (a popular Russian expression which is often used when one refers to himself, or to somebody else, in an ironic manner) straight to the guardhouse where he was placed on a regimen of bread and water." I do not remember," says Sechenov, "how long I spent there, but I recall that when I came out, I found myself demoted: I lost the stripes of my corporal rank."

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[1] Sechenov's knowledge of foreign languages proved very useful to him later in his scientific studies abroad. On his return to Russia he spoke German and French fluently and without accent; he also had a very good knowledge of English. In this respect he was quite different from Pavlov who was a rather poor linguist.

The Head of the school, General L., soon took a dislike to Sechenov because the latter made fun of the general's son, a fellow student. The general considered such an attitude an expression of disrespect to himself. On the ground that a sketch presented by Sechenov at the examination was not according to scale, the general gave him a bad mark in fortification, thereby demoting him to the group of second-rate students. After examination in military construction, Sechenov even found himself in the third rate group. This put an end to Sechenov's studies at the Engineering School, and in 1848 the 19-year-old Sechenov was transferred to the army as a junior sapper officer of the Second Reserve Battalion, stationed in Kiev.

One of Sechenov's fellow officers introduced him to his family where he met his "benefactress," as Sechenov later used to call her. This was his hosts' young daughter, widowed at the age of 20, six months after marriage. Possessing an excellent educational background and a very enthusiastic nature, she exuberantly spoke of the enormous value of science for the future of mankind, of the University of Moscow as the source of culture, and of medicine as the noblest of professions. She pleaded for the emancipation of woman and her admission to higher education, including professional education, and exalted the role which woman can and must play in the life and progress of society.

The sensitive Sechenov was deeply impressed. In fact, all his future career was determined by his meeting with this young woman. In his *Autobiographical Notes* Sechenov writes: "When I first entered this house I was a mere youngster, passively following the road on which my feet had fallen, not knowing where it would lead me. When I left it, my future was planned; I knew where to go and what to do." And, indeed, in February of 1850, after 1½ years of military service, Sechenov retired from the army. He then prepared for the required examinations, and after passing them in August 1851, he was accepted as a student of the Medical Faculty at the University of Moscow.[2]

[2] As will be seen later, Sechenov remained faithful to, and consistently helped in, the realization of the views and aspirations of his "benefactress" with regard to the emancipation of woman and her right to higher education. He very diligently worked and fought for the admission of women to the University of St. Petersburg and took part in an attempt by a group of intellectuals to obtain the permission of the government to open a private university for women. Several years passed before the permission was finally granted and the "Higher Courses" for women, the so-called "Bestuszev Courses" (after the name of the first director), with faculties of philology and natural sciences, were founded. Sechenov undertook to teach physiology at these "Courses." The school was not permitted to confer university degrees on the graduates, and the students came solely for the sake of knowledge. In later years, Sechenov used to say that teaching at the "Bestuszev Courses" was a source of the greatest moral satisfaction to him, an experience which, in his opinion, would change the most ardent adversary of the higher education of women, into a zealous supporter of such education.

During his student years Sechenov had to live extremely modestly. A dish of meat was a luxury which he could permit himself only twice a week, and a cup of tea in which he indulged once in a fortnight, was even a greater extravagance. However, his fervor for his studies easily overcame penury, and in his old age Sechenov often spoke of this enthusiastic period of his youth, which, in his words, taught him the wisdom of being moderate in his desires.

At the Medical Faculty Sechenov worked very hard, never missed a lecture, and spent much time in the dissecting room of the Anatomical Institute. His favorite lecturer was Professor Glebov who held the Chair of Physiology and devoted a part of the year's course to comparative anatomy. Glebov's exposition of the subject was so fascinating that Sechenov at one time even thought of taking comparative anatomy as his specialty. In the third year of his medical studies, when Sechenov began attending lectures in practical medicine, his attitude toward his work changed. The lectures did not arouse any interest; he considered them grossly empirical and scholastic. His heart was in physiology. Sechenov, however, continued his medical studies and successfully passed his examinations for the medical degree in June of 1856.

In August of the same year Sechenov left for Berlin, attracted by the fame of Johannes Müller, whose lectures he attended during 1856 and 1857. He also took Professor Du Bois Reymond's course in animal electricity and carried out a number of electrophysiologic experiments in his laboratory. The rest of his time he devoted to chemistry and obtained Hoppe-Seyler's permission to prepare his doctoral thesis in the latter's laboratory. The subject of the thesis was the influence of acute alcoholic intoxication on the organism. The choice of the theme was apparently dictated by one of the saddest sides of Russian life of that time. In Hoppe-Seyler's laboratory Sechenov worked out a method of determining the alcohol content of exhaled air and a technique for determining the CO_2 output of the intoxicated animal. He also studied the effect of alcohol on the temperature of the body. Furthermore, in the course of his experiments, he worked out an improved technique for the extraction of the gases of the blood, using L. Meyer's absorptiometer as a pump. The results thus obtained were so good that C. Ludwig, the world-famed physiologist, had an improved model, based on Sechenov's principle, built for his laboratory.

Sechenov spent the fall of 1858 in Ludwig's laboratory in Vienna where he was joined by several Russian friends, including the young physician Botkin, later the famous clinician. In the spring of the following year Sechenov was in possession of all the data he needed for his thesis. After nearly a year's work with Ludwig, he left for Heidelberg to work in the laboratories of Helmholtz and Bunsen. In May, Ludwig, who became and remained for life Sechenov's closest friend, wrote him:[3]

> "Dear Sechenov,
>
> Botkin left here, married. I hope he will have a joyous and happy journey. When I saw him here, he told me that Glebov—a high official in the Ministry in St. Petersburg—had written to him to say that you should write him (Glebov) a letter and outline how and where you are working in physiology, so that he can have some record in hand, in order to do something for you. So act accordingly. I asked Botkin that he write you about it himself. I hope he did it, all the more since his wife also insisted on it.
>
> Just as you complained about Botkin's sensitivity so did he complain about yours. Forgive me for telling you this, but I would like so much to achieve an accord between two men who together, each one in his way,

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[3] All letters from Ludwig to Sechenov are quoted after the German originals reprinted in *I. M. Sechenov: Selected Works* (8).

> could do so much good. You know well my opinion on it. So, each one of you believes himself to be the offended one. Well, this is a good omen, a way of getting reconciled with each other.... Please transmit my cordial greeting to Bunsen and Helmholtz and retain in your memory your faithful C. Ludwig. Vienna, May 14, 1859"

Glebov, to whom Ludwig refers in this letter, is the above mentioned Professor of Physiology, Sechenov's teacher, who had been transferred to St. Petersburg as Vice-President of the Medico–Surgical Academy.

Ludwig's reference to Botkin and to the quarrel between the two friends is of interest. Just before Sechenov's departure from Vienna he had an argument with Botkin about the importance of the *cellular* principle in physiology and pathology. Botkin defended vehemently the theory of Virchov, whose pupil and ardent admirer he was, while Sechenov attacked it violently, insisting upon the importance of the physicochemical (Sechenov called it "molecular") nature of the *environment* of the cell. The two friends parted in anger, and Sechenov left Vienna without even saying goodbye to Botkin. Ludwig heard of this quarrel from Sechenov.

Soon after Ludwig's letter, Botkin came to Heidelberg with a letter from Glebov, and the bitter enmity was forgotten. "But since then," writes Sechenov in his *Autobiographical Notes*, "Botkin and I carefully avoided mentioning cells or molecules in our conversations with each other."[4]

The highly impressionable Sechenov soon found that the general atmosphere in Helmholtz's and Bunsen's laboratories in Heidelberg was lacking in that warmth to which he had been accustomed in Ludwig's Vienna laboratory. This affected him so much that he wanted to leave immediately. He wrote to Ludwig asking for advice. His devoted teacher, in a very fatherly way, urged Sechenov to stay and to carry out the work which he had so long contemplated doing. Apparently, Sechenov in his letter to Ludwig had complained of his loneliness in Heidelberg because in his reply Ludwig asks: "Do you not encounter in Heidelberg any compatriots? Is the life in the little town so monotonous?"

As a matter of fact Sechenov did meet compatriots in Heidelberg, one of whom soon became a close friend. This was the young chemist Dimitry Mendeleyev, later the famous author of the Periodic System of Elements now familiar to every high school boy. It was rather "coldness" in the immediate surroundings of his laboratory work which depressed Sechenov and induced him to write to Ludwig. On the insistence of Ludwig, Sechenov stayed in Heidelberg and carried out in Helmholtz's laboratory very important research work on the fluorescence of the eye lens, which was highly praised by Helmholtz.

In the winter of 1860 a family misfortune struck Helmholtz. His wife fell ill and soon afterwards died. The following letter from Ludwig to Sechenov refers to this event, and incidentally, sheds light on the character of Helmholtz and on the enormous esteem and devotion which his scientific colleagues entertained for him.

> "Dear Sechenov,
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> We have had today a very sad day indeed. The news of the death of Helmholtz's wife has greatly affected me. A

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[4] Sechenov's views relating to Virchov's theory are clearly expressed in the following statements in his dissertation for the degree of Doctor of Medicine (1860):

"The animal cell is an anatomical, not a physiological unit; physiologically it is of no less and no more significance than its environment—the intercellular substance.

"The principles of cellular pathology are erroneous because they are based on the assumption of the physiological independence of the cell, or at least of its domination over the surrounding milieu. The theory of cellular pathology is an extreme expression of the purely anatomical trend in physiology.

"The only correct approach to pathology in our time is the molecular principle."

> man so deep feeling and so noble, for whose well-being we all tremble, could hardly be stricken a more cruel blow. I will be very grateful to you if you let me know how he bears his fate. I enclose a letter to Helmholtz, which please deposit in his apartment....
> In all faithfulness, your C. Ludwig.
> January 3, 1860"

SECHENOV'S EARLY ACADEMIC ACTIVITY. RESEARCH WORK IN PARIS. FIRST GREAT SCIENTIFIC ACHIEVEMENT: THE DISCOVERY OF SPECIFIC MECHANISMS OF CENTRAL INHIBITION (1860–1863)

When Sechenov's financial resources were exhausted, he left Heidelberg and returned to Russia. He arrived in St. Petersburg in February of 1860 and submitted the manuscript of his dissertation, "Data for the Future Physiology of Alcoholic Intoxication," to Professor Glebov. A month later the public debates on the dissertation took place, and soon afterwards Sechenov was appointed Assistant Professor of Physiology at the Medico-Surgical Academy. He began his lectures in March.

Both by their form and content Sechenov's lectures produced an enormous impression on his audience. With youthful enthusiasm and deep faith in the potentialities of science he called upon his pupils not to be afraid of exploring Nature in its most complex and seemingly mysterious expressions, to formulate questions unhesitatingly, and by boldly devised experiments to extract definite answers from Nature.

A very vivid description of Sechenov, the lecturer, is given by A. F. Samoylov, a pupil of Sechenov and co-worker of Pavlov. Stating that it is difficult to describe Sechenov, he says: "One had to *see* Sechenov! His eyes and their sharp look cannot be described in words. His face was immobile and yet it remarkably reflected his mood, and his mood changed quite often. His face was beautiful when he was good or, more exactly, when he was in a good mood. He loved to be good. He valued greatly goodness in others. He was in his very essence a good man, but his excitability, his explosiveness, his apprehensive and to some extent, even suspicious nature, hindered him in remaining always at the height of his natural goodness. He sometimes was very stern. He was in his way beautiful in such moments of sternness and harshness, in moments of anger and indignation which would break through in him especially when he was faced with injustices committed by the authorities. Then his eyes would truly throw sparks."

"Very soon," continues Samoylov, "I started attending his lectures to students, for which, as an assistant, I had to prepare the experiments. There was no limit to my amazement and my delight. Even now, after so many years, I must admit that neither before that time nor at any time afterwards have I encountered a lecturer of such talent."

And yet Sechenov was not an orator. He spoke quietly, evenly; he never raised his voice. His phrases were short and pointed, and his diction was perfect. But the principal source of his success as a lecturer was the unique persuasiveness of his logic.

Sechenov's greatest gift, however, was not his talent as a lecturer but his remarkable ability to teach the young and inexperienced research workers to conduct independent investigations. In this respect it can rightly be affirmed that Sechenov was the founder of the Russian School of physiologists, later headed by Pavlov. The Medico-Surgical Academy owed much of its prestige to the joint effort of Sechenov and his friend Botkin. During Sechenov's years as professor at the Academy, physiology became a favorite course of the students.

During the years 1860 to 1863, the doors of the Medico-Surgical Academy were opened to women. Sechenov was a warm supporter of higher education for women; indeed, the first two scientific papers from his laboratory were by women. One of these was Maria Alexandrovna Bokova who later became Sechenov's wife.

After 2½ years of strenuous work at the Academy, Sechenov obtained leave in the fall of 1862 and went to Paris, where he worked through the winter in the laboratory of Claude Bernard. In this laboratory Sechenov carried out his famous experiments on the nervous centers that inhibit reflex movements. The results of these investigations were published in an article entitled "Physiological Studies on the Inhibitory Mechanisms in the Brain of the Frog, for the Reflex Activity of the Spinal Cord."[5]

The fact that the brain exerts an inhibitory effect upon the reflex activity of the spinal cord was already known in Sechenov's time, having been demonstrated by several important observations. It was known, for instance, that the decapitation of an animal produces an increase in its reflex movements. Weber, who had demonstrated the inhibitory effect of the vagus nerve on the heart had also called attention to the fact that, through mere will power, a person is able to exert an inhibitory influence on the motor reflexes of the spinal cord. From these facts Sechenov concluded that there must exist in the brain specific inhibitory mechanism through which such effects are exerted. The objective of his experiments was to identify these mechanisms and to ascertain their exact location.

Frogs were used as experimental animals. The experimenter, after laying bare the cerebrum of the animal, made transsections at different levels of the brain, and observed the effect which the stimulation of the transsected areas exerted upon the spinal reflexes of the animal. For the demonstration of this effect Sechenov utilized Türck's method, according to which one dips one of the hind legs of the vertically suspended frog into a weak aqueous solution of sulphuric acid. Under the chemical action of the acid the frog, by a reflex movement, withdraws the leg from the liquid. The strength of the reflex is determined by counting the time (in seconds or in beats of a metronome set at a certain frequency) which has elapsed from the beginning of the stimulation to the moment of reflex response. The stronger the reflex, the quicker the leg is pulled out of the acid solution.

Sechenov stimulated the areas laid bare by the transsections with a solution, or a wetted crystal of NaCl, and found that, when placing the NaCl crystal upon the thalami optici, or on the corpora quadrigemina (with lesser effect), or on the medulla oblongata (with still less effect), the spinal reflex of withdrawing the leg from the acid was weakened. This manifested itself by the fact that between the moment of dipping the frog's leg into the solution and the moment of its withdrawal by the decapitated animal, much more time elapsed than usual. Sechenov concluded that the excitability of the spinal cord, where the withdrawal reflex took place, was lowered by the stimulation of the thalami optici, so that more time was needed for the chemical stimulus to reach the intensity sufficient to bring about the reflex.

Sechenov further showed that if the NaCl is removed from the thalami optici (with a few drops of water and filter paper), the depression of the spinal reflex gradually disappeared; it could again be produced if the stimulus was again applied, but in a stronger concentration than the previous one. In one experiment, Sechenov succeeded in provoking the depression of reflex activity in the same animal three times in succession during one and the same experiment. He also noted that when the first stimulation of the thalami optici was strong and the following one was weak, the latter was unable to exert an effect upon the reflex activity of the spinal cord.

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[5] "Physiologische Studien Uber die Hemmungsmechanismen fur die Reflextatigkeit des Ruckenmarks, im Gehirne des Frosches."

They were also published in French: Note sur les Moderateurs des Mouvements Reflexes dans le Cerveau de la Grenouille, in the Transactions of the French Academy of Sciences, 1863, where Sechenov's communication was presented by Claude Bernard.

These observations convinced Sechenov that the mechanisms for the depression of the reflex activity of the spinal cord are located in the thalami optici (and, to some extent, in the corpora quadrigemina, and partly perhaps also in the medulla oblongata).

When his stay in Paris came to an end, Sechenov went first to Vienna to show his experiments to his teacher and friend, C. Ludwig, and to Brücke. He then went to Berlin where he demonstrated them to Du Bois Reymond. These demonstrations aroused great interest among the Western European physiologists, and in Sechenov's own mind they gave rise to several most important theoretical conclusions which formed the basis of his ingenious work entitled "Reflexes of the Brain".

PUBLICATION OF THE ESSAY "REFLEXES OF THE BRAIN," ITS BASIC TENETS. THE CONCEPT OF CEREBRAL ("PSYCHIC") REFLEXES, AND ITS IMPLICATIONS. VOLUNTARY AND INVOLUNTARY ACTS. THE QUESTION OF "FREE WILL" AS A NEUROPHYSIOLOGIC PROBLEM.

After repeatedly observing the expedient character of the machine-like reflex movements and the seeming "intelligence" of many of these movements in an animal deprived of its brain; and after taking into account that the stimulation of certain brain centers regularly and inevitably arrested such movements, Sechenov inferred that both kinds of action must be viewed as typical reflexes—excitatory in the first case, and inhibitory in the second. Considering further the fact that human beings may, through will-power, inhibit spinal reflexes or even produce movements contradicting them, Sechenov conceived the idea that both, the described *reflex effects* in the animal and the so-called *voluntary acts* of human beings, are basically one and the same phenomenon, namely a *reflex act*. The difference is merely in the location of the reflex. In the spinal cord, it appears as a clearly machine-like process; when located in the brain, on the other hand, it gives the impression of a voluntary act, especially when it is associated (as may or may not be the case) with the element of consciousness. Thus, we may speak of two classes of reflexes; lower reflex acts, such as spinal reflexes, and cerebral reflex acts, or "psychic" reflexes.

On November 23, 1863, Sechenov's article, "Reflexes of the Brain," appeared in the Petersburg medical journal, "Meditzinsky Vestnik" (Medical Herald). The basic tenets of this product of Sechenov's "swing of the thought of a genius," to use Pavlov's expression, may be summarized as follows:

The object of a scientific study of psy-

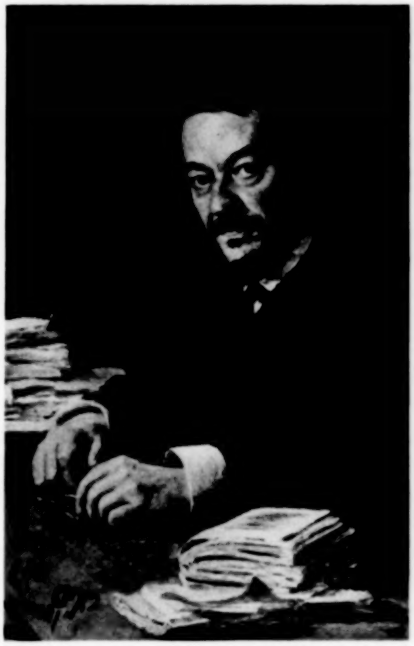

Fig. 1. I. M. Sechenov. Portrait by I. Repin (1889), Tretiakov Art Gallery, Moscow. Reproduced from *I. M. Sechenov: Selected Works*. State Publishing House, Moscow, 1935.

chic activity is not, and should not be, the inner essence of what one calls "psyche"—a problem which is of a purely philosophic interest—but rather the expression of such activity, or, more exactly, the external manifestations of psychic life. This is important since only by such external manifestations do we form an opinion about the psychic processes taking place in another person.

Sechenov takes for granted that all manifestations of psychic life are determined by the activity of the brain. Whether one considers the brain merely as an organ of the spirit separated from the brain, as some people do; or one considers the spirit as a product of the brain, as other people assert, is a question which does not concern the physiologist. In both cases the brain represents a mechanism which, when brought into action, regardless of the nature of the cause, produces as a final result that series of external phenomena characterized as psychic reactions and finding expression in innumerable movements of the most varied kind and intensity. "All the endless diversity of the external manifestations of the activity of the brain," says Sechenov, "can in the final analysis be regarded as one phenomenon—that of *muscular movement*. Be it a child, laughing at the sight of toys, or Garibaldi smiling when he is persecuted for his excessive love for his fatherland, a girl trembling at the first thought of love, or Newton enunciating laws and writing them on paper—everywhere the final manifestation is muscular movement."......"Even the most confirmed spiritualist must concede this."

Sechenov then logicaly concludes that, in order to understand the activity of the brain as the organ of psychic experience one has to carry out a thorough study of the most varied movements by which man's psychic life manifests itself. These movements, from a physiologic viewpoint, can be divided into two main groups, voluntary and involuntary. Consequently, the brain physiologist's task is to investigate the origin of both groups of movements.

The analysis of the involuntary movements is relatively easy, and we very frequently watch their machine-like course in everyday life. Each time when an unexpected strong stimulus, say the sudden knocking on the door or the flashing of a strong light, acts upon an animal or a human being, there is an automatic motor reaction to the new stimulus on the part of the organism. No one doubts the reflex nature of the movements performed. In their pure, elementary form they are produced through the spinal cord, which is demonstarted by the fact that they can be obtained also in the decapitated animal. This can be shown with particular clarity in experiments on frogs because in this animal the spinal cord, the nerves and muscles respond for some time after decapitation. If one does not touch the decapitated frog's skin, it will sit without movement for a long time. But if one touches the skin, the frog will immediately move, and then again sit quietly. If one pinches the skin more strongly, the animal will jump as if it were trying to escape from pain. When the effect of the stimulation (the "pain") has passed the animal remains motionless for hours. Obviously, the animal cannot feel pain since the conscious sensation of pain is located above the spinal cord. These movements are therefore reflex, involuntary, machine-like. The three integral parts of the classic reflex arc are perfectly manifest in all such cases: the external stimulation, running centripetally to the center-receptor in the spinal cord, providing the first link; the transmission of the stimulus within the spinal cord from the center-receptor to the center-effector, supplying the second link; and the stimulation running centrifugally from the center-effector to the peripheral organ, the muscle, representing the third and final link.

The problem becomes much more complex when we are faced with voluntary movements through which a person expresses his free will. These movements, which never bear the character of machine-like, reflex acts, are characterized by three principal features:

1. In contrast to involuntary reflex movements, they are purposive, rational.

2. They not only are not machine-like, but on the contrary, they are capable of counteracting involuntary reflexes, of retarding them, of diminishing their intensity or of arresting them entirely.

3. No external stimulus is necessary to produce them, as is the case of involuntary movements. The person freely conceives and executes them.

At first sight the above characteristic traits seem to point to complete disparity of the two groups of movements. However, a closer analysis shows that with regard to each and every one of the three enumerated characteristic features there is no essential difference between the involuntary movements and the so called voluntary acts. Indeed, let us analyze separately each of the three features just outlined.

1. The voluntary movements are rational, purposive. This is correct, but it is easy to show that the involuntary, reflex movements are likewise always expedient. By such movements the animal or human being tries either to prolong a pleasant sensory stimulation or to eliminate an unpleasant, irritating, noxious stimulus. When in answer to the sudden stimulation by a flash of strong light a person carries out a swift movement with his eyelids, closing the eyes, this movement, although obviously involuntary and of a purely reflex nature, is highly purposive and rational since it protects the eye against possible harm that might be caused by the strong illumination.

What is more, the same rationale and purposiveness characterize reflex movements carried out by a decapitated animal in which the nature of the movements is determined fully by the spinal cord. Pinch the leg of a decapitated frog; by a simple movement it will attempt to remove the leg from the source of irritation. Smear the same leg with acid; the frog will then, during a long time, wipe the smeared leg against some other part of its body, attempting to get rid of the acid. Consequently, says Sechenov, the brain is not necessary to distinguish between a pinch and an acid irritation. Thus the apparent rationality of a movement does not exclude the machine-like character of its origin.

2. Voluntary movements, as expressions of the person's "free will," often combat reflex movements, attenuating them or even completely arresting them. This argument sounds very logical. Indeed, let us imagine a person standing in the middle of a room, entirely unaware of what is taking place behand him. If we suddenly push the person vigorously from the back, he will be flung several steps from the place where he stood. It is a different matter if the person knows that he will be pushed. Then he will so adjust his muscles that even a much harder push will not move him from the place. In this case, in other words, the person exhibits an active and intentional counter-action to the external stimulus, which is shown by the contraction of a special group of muscles resisting the effect of the stimulus. However, in a strict sense these voluntary movements are also "machine-like" since they are fully determined by the given conditions. Each time the person will expect to be pushed, that is, each time he will find himself in the same set of conditions he will display the same counter-action. The real explanation of this inhibitory effect exerted upon the involuntary reflex movements, lies in the fact that a second mechanism enters into play, which restricts and retards the reflex caused by the stimulation. This mechanism must be located in the brain since the "will" acts

only through this organ. Sometimes this restricting mechanism is stronger than the stimulation; then the reflex, that is, the involuntary movement, does not occur. Sometimes the opposite takes place; the stimulation proves stronger than the counter-action, and the involuntary movement appears. But we must always bear in mind that similar inhibitory mechanisms have been shown to exist also in the brain of the frog, notably in the thalami optici. The stimulation of these mechanisms in a decapitated frog causes the same retardation or arrest of the spinal reflexes as is observed in normal animals or in human beings.

3. Voluntary movements presumably differ radically from involuntary reflex acts in that the latter require an external stimulus for their production, whereas the voluntary movements are in no need of an external stimulus, being produced at any time by the person's free will. Sechenov denies this latter assertion. Voluntary movements also require an external stimulus and depend on it, although the stimulus may not be easily descernible. Sechenov explains this as follows:

Every external stimulus such as a sound or an image, after it has produced a specific impression in the brain, is retained there in the form of a material trace. This cannot be otherwise. If it were, that is, if the impression ended completely with the cessation of the external stimulus; no memory, no reproduction, would be possible. It follows that the more frequently a certain impression is repeated, the clearer and more definite becomes the image retained, the deeper and more intense becomes the trace established in the brain.

The traces left by the external stimuli account for innumerable expressions of psychic life. Sechenov cites an example to illustrate this idea, and while doing so, actually formulates the principle of the conditioned reflex, later adopted by Pavlov and made by him the very foundation of all his investigations. Sechenov says:

"It is known that the feeling of cold often produces in people the so-called 'goose-skin,' that is the contraction of very small muscles in the skin. This phenomenon is undoubtedly reflex, and, as such, is entirely involuntary, though it is complicated by the conscious sensation of cold. Yet, I know a gentleman who is capable of provoking in himself 'goose-skin,' even in a warm room, simply by imagining that it is cold. In this interesting example, imagination produces the same effect as actual sensory stimulation. What then is the nature of the process by means of which psychic formations are reproduced in memory? This process is essentially the same as in the case of any sharp psychic formation called forth by the action of an external agent upon the corresponding sense organ; in other words, it is likewise a process of excitation of central nervous mechanisms.

"I consequently assert that, from the point of view of the phenomena which take place in the central nervous system, it is *immaterial* whether I *actually see* a man before me or *merely remember him*. The only difference is that among the many sensations which are produced in me by the actual presence of the man, the optical sensations are especially sharp and clear because my optical attention is supported by the visual stimuli. When I do not see the man and only remember him, the *first stimulus* that brings him back to my memory is generally the action upon me, at a given moment, of *one of the external stimuli which were acting upon me at the time of my first encounter with that man.*[6] *This stimulus calls forth all the complex of sensations which was produced in me by this man and which is preserved in my central nervous system in the form of traces.* The sight of this man, his words, the movements of his face or hands, etc., arise in turn in my consciousness. . . . I repeat once more: as far as the process is concerned there is not the slightest difference between an actual impression (including its sequelae) and the memory of this impression. We have the same *psychic reflex* in both cases, with the same psychic content. Only the stimuli which arouse them are different. I see a man because *his image* is actually pictured on *my retina*; I remember him because my eye has caught the *image of the door near which he stood.*[7]

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[6] A very clear formulation of the principle of a conditioned reflex, which is the coincidence in time of an indifferent external stimulus with a state of excitation of one or several nervous centers, for instance a certain sensation or complex of sensations.

"The question whether voluntary movements are really based on the stimulation of sensory nerves is therefore answered affirmatively. It also becomes clear why, in the case of voluntary movements, this sensory stimulus is often unnoticeable."

The mechanism of inhibition, according to Sechenov, plays a great part in the origin of voluntary movements. While some people will scream and writhe when sustaining pain, others, possessing a strong "will," may triumph over seemingly irresistible involuntary movements. "There are even men who can endure pain, performing at the same time movements which are entirely incongruous with pain, such as joking and laughing."

Sechenov foresees the following question: If the brain contains specific mechanisms which inhibit muscular movements, then why is the activity of these mechanisms so unequally expressed in different people? If the inhibition of movements is an organic feature common to all people, then it would seem that this phenomenon should not present such considerable variations, as, for instance, in the case of a weak, nervous individual on the one hand, and that of an impassive stoic on the other. Besides, it should also be present in children.

"The fact is," says Sechenov, "that inhibition does exist in all cases, but we must *learn* to *inhibit* movements just as much as we *learn* to *perform these* movements. No one will doubt that a newborn child possesses the nervous centers which later regulate the acts of walking, speaking, etc., and yet, these acts also must be learned."

The advantage which man has derived from learning to inhibit the last stage (the movement) of his reflexes, is in Sechenov's opinion, enormous. "He has acquired thereby the *capacity to think, to reason and to judge*. For what is indeed the act of reasoning? It is a consecutive series of connected ideas and conceptions which exist in our consciousness at a given time, and which receive *no expression in external acts*." In other words, in a thought, we have both the beginning of a reflex and its continuation, but the end of the reflex (that is, the movement) is absent. "A thought is the first two thirds of a psychic reflex."

Emotions, according to Sechenov, are augmented reflexes, and therefore they are manifested outwardly by movements which are stronger than usual. Sechenov terms them "psychic reflexes with augmented end."

There are thus three main groups of "psychic reflexes":

1. the classic psychic reflexes, with the usual three links in the reflex arc; 2. the psychic reflexes with augmented end—the emotions; and, 3. the psychic reflexes without the end link,—the thoughts.

As a result of his analysis, Sechenov arrives at the conclusion that even the most voluntary of all actions of man depends completely upon external and internal conditions. "Even the external activity (that is, the movements) of a man with an ideally strong will, who is acting on some high moral principle and is clearly conscious of every step he takes, in other words, an activity which can be said to be voluntary in the highest degree, can be explained by the same mechanism which is valid for involuntary movements," and this for two reasons:

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[7] An excellent example of a conditioned response in which the sight of the door serves as a conditioned stimulus that evokes the image of the man (deposited in the form of material traces) with whom this stimulus repeatedly coincided in time.

1. This type of activity, as shown, is composed of reflexes which begin with a sensory stimulation, continue by means of a definite psychic act and end in muscular movement.
2. A given sensory stimulus inevitably leads to the other two components of the whole phenomenon, and always in the same sense, provided that the external and internal conditions are the same, that is, the environment in which the action takes place and the physiologic state of the person who is performing the action, have remained unchanged. "This means," says Sechenov, "that under similar external and internal conditions man must act in the same way.... The choice of many possible ends of the same psychic reflex is definitely impossible, and its apparent possibility is only an illusion of our consciousness."

Thus, according to Sechenov, there can be no question of a man's free will.

The views of Sechenov are interesting in more than one respect. Operating with very scanty factual data obtained in experiments on decapitated frogs, Sechenov ventured to draw conclusions from these data of the greatest general biologic and psychobiologic significance; conclusions which have a bearing on the understanding of the most complex forms of human behavior and on the solution of such fundamental philosophic problems as the question of free will.

It should be noted that the specific interpretations given by Sechenov to the different phases of the experiments themselves, would, at the present state of cerebrophysiologic investigation, have to undergo considerable modification. And yet, the conclusions drawn from these experiments, as far as their general biologic significance is concerned, remain valid even now. These conclusions and concepts form the ideologic background of that vast field of knowledge which has been opened by the conditioned-reflex investigations of Pavlov. This fact clearly highlights the caliber of Sechenov's scientific mind, the extraordinary power of his analysis and that typical trait of true genius, which permits one, from a few apparently minor experimental findings, to derive notions and concepts extending their significance over an immense world of natural events.

IMMEDIATE IMPRESSION PRODUCED BY THE PUBLICATION OF "REFLEXES OF THE BRAIN," AND ITS INDIRECT EFFECTS AND REPERCUSSIONS. SECHENOV'S WRITINGS UNDER "SUPERVISION" OF THE AUTHORITIES. ADMINISTRATIVE MEASURES AGAINST "REFLEXES OF THE BRAIN" AND COURT ACTION AGAINST THE AUTHOR.

The impression produced by Sechenov's article upon the scientific world and upon the intellectual circles of society in general was enormous. The views expounded by him were so novel and so daring, his analysis of psychic life was so appealing and convincing and the presentation was made with such talent, that the work rapidly became known over all of Russia. But this success soon became the source of endless trouble for Sechenov, of innumerable physical privations and of great moral suffering. Sechenov had to endure these to the end of his life.

The primary cause of the trouble stirred up by his article in the "Medical Herald" was the fear it aroused in the minds of the authorities. They considered Sechenov's views extremely dangerous, and asserted that these views presented a menace to the security of the country. The authorities held that his views corrupted the morals of society and repudiated the principles of Christianity. In consequence Sechenov's writings were put under "police supervision."

Ludwig heard of the difficulties and annoyances sustained by Sechenov, and expressed his feelings in the following letter:

> "Most esteemed friend,
>
> Although I was overjoyed when you

> informed me of the publication of your work, my pleasure became particularly vivid when I held these most important pages in my hands. Reading your work, I again recalled the beautiful experiments which you showed me, and, with the help of the written instructions you had given me, I was able to demonstrate your findings in my most recent classes. I do not have to suggest to you that you continue in your path in which still more discoveries are assured to you...
>
> What was there in the newspapers about you? I was told—I did not read it myself—that your writings have been placed under a special supervision. Well, such a true friend of his country should not be brought to this point. At least, I am glad that you feel well...
>
> Your true and devoted C. Ludwig.
> Vienna, November 15, 1863

The apprehension of the authorities, aroused by Sechenov's publication, reached its climax three years later when Sechenov's work appeared in book form. The Petersburg Censorial Committee prohibited the sale of the book and at the same time summoned the Attorney-General, Tisenhausen, to institute proceedings against Sechenov on the following grounds:

Mr. Sechenov's treatise is an attempt to explain the psychic functions of the brain by reducing these functions to muscular movements produced in response to external material stimuli. In other words, he regards all human acts, without exception, as purely mechanical processes. According to the author, every human action is caused by some external sensory influence, without which thought is impossible. He says: 'Love of truth, goodheartedness, compassion, as well as the hatred of all opposite features of character, are developed by means of frequent repetition in our consciousness, of emotional images (optical and acoustic), representing in a vivid form the virtues enumerated above;' and further: 'at the basis of our passionate adoration for good deeds and aversion for vice, there is nothing else but an exceptionally long series of psychic reflexes.' According to Mr. Sechenov, the so-called 'deep convictions' also belong to the category of impressions called forth by accidental external influences. Such are the author's final conclusions.

"He does not say a single word about the role of other factors in mental and spiritual processes. Even though he acknowledges the existence in men of a certain type, of high moral principles, acquired by them in the course of life (that is, developed by means of the same accidental psychic reflexes), he still regards the behavior of such men as an inevitable result of these principles; thus he says: 'The presence of these principles makes it impossible to act in any other way; the behavior of man is an inevitable consequence of these principles....'

"This materialistic theory reduces even the best of men to the level of a machine devoid of consciousness and free will, and acting automatically. It sweeps away good and evil, moral duties, the merit of good deeds and the responsibility for bad ones; it undermines the moral foundations of society and thereby destroys the religious doctrine of eternal life; it militates against the views of Christianity and the demands of the Penal Code. Consequently, it leads to the corruption of morals.

"Mr. Sechenov has given his theory the form of a scientific treatise; but its style it far from scientific; it is written so as to be easily understood by the layman. This fact, and the low price of the book (80 kopeks; about 40 cents. *Ed.*) prove that the author's intention is to make his theory accessible to a wide circle of readers. It follows that Mr. Sechenov's book, "Reflexes of the Brain,' is directed to the corruption of morals; it is indictable as dangerous reading for people without established convictions, and, as such, must be confiscated and destroyed under article 1001 of the Penal Code."

In the beginning Sechenov did not take too seriously the action initiated against him, and certainly did not visualize the consequences. When a friend asked him whom he intended to engage as an attorney for his defense at the trial, Sechenov replied: "Why do I need an attorney? I will take a frog with me to Court and will carry out before the judges all my experiments. Then let the public attorney refute my conclusions."

Sechenov presented a copy of his book to the young woman whom he later married. In it he inscribed the following revealing addendum: "In conclusion, I wish to reassure the moral feeling of my reader. The notion which I have expounded does not destroy the value of human virtue and the morals: the foundations of our love for each other are eternal. In the same way, man will always value a good machine better and will prefer it to a bad one, when he has the choice. But in addition to this negative merit of my doctrine let me state a positive one—only my point of view explains how man can acquire the greatest of all human virtues—all-forgiving love, that is absolute understanding of the weaknesses of his neighbors."

It is interesting that the Attorney-General did not accede to the request of the Censorial Committee and informed the Head of the Ministry of Justice, Prince Urussov, that Sechenov's work did not transgress the exact meaning of any of the articles of the Penal Code, and that no action could be taken against the author. He gave the following reasons:

"1) The author does not repudiate in his book the principles of morality and religion, nor does he question the immortality of the soul. He does not dispute the doctrines of Christianity, or deny the accountability for criminal actions. The purpose of the treatise is solely to explain the action of external stimuli upon the nervous system and the reflection of this action in the brain as the organ of thought. It does not deal with the human soul; indeed, the author himself writes in the treatise that he hopes the representatives of the science dealing with the soul will point out the defects of his work. Consequently, Sechenov's doctrine, if it is erroneous, must be dealt with by means of scientific discussion, and not by means of legal procedure in the Criminal Count.

"2) Even if it is proved that the author defends the teaching of materialism, he cannot be indicted under the present Penal Code, because this Code does not condemn the defense of materialist views as such, if this defense is not accompanied by direct repudiation of morality and Christian principles.

"3) The article of the Penal Code invoked by the Censorial Committee can in no way be applied to the present case, for this article relates only to those authors whose published books or articles are openly immoral or indecent. There is not a single line in Professor Sechenov's treatise which could be condemned from this point of view."

After receiving this opinion from the Attorney-General, the Minister of Justice wrote to the Minister of Interior, giving his support to the Attorney-General's view and advising that the action against Sechenov be discontinued. He gave an additional reason for dropping the action, a reason of a more practical nature: he was in doubt about the outcome and the implications of such Court action, "all the more so," he pointed out, "since an open trial of Sechenov's book would merely draw public attention to it and thereby lead to further dissemination of materialistic doctrines in society." He added that the book was undoubtedly harmful but that its style was so ponderous and scholarly that it would hardly become popular reading if it were left to its own fate. The decision of the Minister of Justice was approved by the Minister of the Interior, and the Court action against Sechenov was abandoned.

A rather curious feature in the above affair is that the Attorney-General displayed a very liberal, almost sympathetic, attitude toward the author of "Reflexes of the Brain." In fact, the Attorney-General's attitude, as will be seen later, was incomparably more understanding than that exhibited by the academic groups. Professional jealousy and petty personal interests played their part in these latter groups to the full; the Attorney-General was free of such feelings.

SECHENOV'S ACADEMIC ACTIVITY AFTER THE PUBLICATION OF "REFLEXES OF THE BRAIN." HIS TRIP ABROAD AND RESEARCH ACTIVITY IN GRAZ. EXPERIMENTS ON THE RELATIONSHIP BETWEEN THE CENTRAL AND PERIPHERAL NERVOUS SYSTEMS. SECHENOV'S FURTHER BIOPSYCHOLOGIC STUDIES. (1863–1868)

After his return from Paris, Sechenov resumed his intensive research and teaching activity at the Medico-Surgical Academy. Together with his pupils he published a number of studies devoted to the physiology of the central nervous system. But soon an event occurred which affected Sechenov very deeply—the Government cancelled the right of women to admission to the Medico-Surgical Academy. This frustrated the plans of the women—students of Sechenov—who were working in his laboratory and who had already passed the entrance examinations. Among these students was his young wife, and the impulsive Sechenov was ready to send in his resignation and to go with her to Vienna. There he might work in Ludwig's laboratory, while his wife could study obstetrics or work in a related field. He immediately wrote to his old teacher and received from him the following reply:

> "Dear Sechenov,
>
> I hasten to answer your letter after having made inquiries about the Institute for Midwives. In Vienna, only those can study midwifery who enter the Institute headed by Professor Spath in a department of the General Hospital. Those who want to enter must be here between the first and the eighth of October....
>
> It gives me infinite sorrow to learn that they have abolished your physiological teaching for women. What do these troublemakers think, anyway? Precisely through such efforts as yours it would have been possible to give St. Petersburg a particular character. I hope that the will of the cultured world will be stronger than that of the police; each time the former acted in earnest the officials, at least in our country, have proved too weak to stop such action.
>
> Even more do I feel sorry that you have been so strongly affected by this matter that you intend to leave the Academy. After all, there is your real and proper ground, and you must cling to it with all your energy....
>
> Your old and faithful, C. Ludwig.
> Vienna, November 2, 1864"

Ludwig's categorical advice to cling to the Academy with all his energy was to a great extent responsible for Sechenov's decision not to retire.[8] He continued to apply himself to his work, translated several German monographs into Russian and wrote a textbook for his students, entitled, *Course of Physiology of the Central Nervous System.*

At this time Sechenov's health failed, apparently from overwork, and he took a year's leave and went abroad for medical treatment. After a cure in Carlsbad his health rapidly improved and, instead of prolonging his vacation, he went to Graz to work in the laboratory of Professor Rollett, an old friend of the Vienna period. There he carried out a series of experiments on the relationship between the central and the peripheral nervous systems (1867–1868), which represented a further development of his research on the inhibitory centers. This investigation is very graphically reflected in Sechenov's letters to his wife,[9] in which his characteristic scientific enthusiasm is mixed in a very spontaneous and candid way with his personal joys and his tender affection for his correspondent.

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[8] A few years later Sechenov's wife went to Switzerland and finished her medical studies there. After graduation in Zurich in 1871 she returned to St. Petersburg. She was the first woman physician in Russia.

In one of these letters, dated October 12, 1867, he writes:

> "Imagine, for instance, the following picture: one half of the spinal cord of a frog is transsected, and then the brain is cut through in that place from which, by stimulation, one obtains the inhibition of the reflexes. Two minutes after cutting through the brain you can place the frog on the table, right before your eyes, and observe, at your heart's desire, even for 24 hours, the beating of the lymphatic hearts on both sides. Now, you put salt on the transsected brain—the frog does not move from the spot—one heart, on the transsected side, continues to beat, and the other is at a standstill. The salt is left where it is .... On the side of the arrested heart one can now pinch the leg of the frog very forcibly, even cut it with scissors, and the frog does not react; but the leg of the opposite side strongly reacts to a simple pinch. Take the salt out of the wound, and leave the frog for about ten minutes. The depression of the spinal cord gradually passes, and the stimulation of the previously insensitive leg begins to provoke a weak reaction. At this time the pinching of the skin brings about two or three contractions of the previously arrested heart. Is it not clear that, as long as the stimulation of the brain acts upon the excitability of the spinal cord in a strongly depressive manner, it is impossible to provoke from the periphery the excitation either of the reflected [*i.e. motor. Ed.*] apparatus or the mover of the lymphatic hearts; but, as soon as the effect begins to weaken both become possible. Do you understand, my beloved little baby, that these experiments, by their importance, could well compete with those which I carried out in Paris, and in their elegance they overshadow all that is known to me in physiology to this date (with regard to the nervous system)!"

Equally characteristic of Sechenov's scientific faith, fused with personal emotions, are the following two letters relating to the same period.

In the first of these, dated January 30, 1868, Sechenov writes to Maria Alexandrovna:

> "...I have carried out the following experiment. I transsect, in the frog, the thalami optici. I also lay bare the sciatic nerve. If I stimulate the latter from the start with an induction current of medium strength or with a strong current, the frog perceives this stimulation and carries out a jumping movement; but if I begin to stimulate the nerve extremely weakly and only gradually increase the current, the frog remains immobile even at the strongest currents. In other words, at a gradual increase of a weak stimulus, the mechanisms which paralyze movements are excited more quickly than those which bring them about.
>
> What do you say to this? It looks as if the dreams which appeared before me when I wrote 'Reflexes of the Brain,' are coming true."

Of particular interest is the second of the two letters, dated February 29, 1868. In this letter Sechenov describes to his wife the experiment of the "White Lady." Sechenov gave this poetic name to his experiment on the frog because on that day he attended a performance of Boieldieu's opera "La Dame Blanche."

> "Here it is," says Sechenov, turning to the description of the experiment, "if one removes the cerebral hemispheres of the frog, the animal, as you

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[9] Quoted from Koshtoyants (3). The original letters, in possession of Professor O. P. Molchanova, were first published in 1946.

> know, sits perfectly quiet. One lays bare, in such a frog, the n. ischiadicus, one cuts through it in the subpatellar fossa and one cuts off the thigh as high as possible. If now one stimulates the n. ischiadicus with a weak current or a current of medium strength, the frog runs away, that is it makes a jumping movement at the very first instant of the stimulation; but if one acts on the nerve with a strong current, the frog remains on the spot and runs away only when the stimulation has ceased. A simpler and clearer experiment of a reflex inhibition of the walking movements can, of course, not be imagined. I believe that the experiment of the 'White Lady' will please even you, my severe bellina.... So you see, beloved, you do not have to worry about my work. Beside the fact that this work solves the problems of reflected inhibition of reflexes and of the act of walking, it contains elements for the analysis of the phenomenon of spinal coordination (that is of alternating movements of flexion and extension of the extremities through stimulation of the skin.) It is thus proved in the most positive manner that the inhibition of reflexes, the arrest of the lymphatic hearts and of the blood heart, by the stimulation of the middle portions of the brain is a result of stimulation of specific nervous centers. Finally, in this work there will be raised entirely new problems about the relationship between the apparatus of walking and the reflex mechanisms. I am only afraid that this matter will drag out, since 'the deeper into the forest the more wood.' Well, it is after all not so bad if because of this work I will have to spend a fortnight at the other one."

The experiment of the "White Lady" absorbed all of Sechenov's attention at the time, and led him to the assumption of the existence of inhibitory centers in the spinal cord as well. It further led him to one of the basic physiologic problems relating to the regulation of coordinated movements. Sechenov demonstrated his experiments to many foreign and Russian scientists. Mechnikov, who visited Sechenov in Graz in 1868, was jubilant. He even conceived the idea of devoting himself to physiology. This is reflected in Sechenov's letter to his wife, dated March 17, 1868. He writes:

> "Mechnikov left here yesterday morning. He intends to start working in my laboratory in September, and altogether begins to dream of becoming a physiologist. Of course, I encourage him in this idea in every possible way, since he is a very talented gentleman, indeed."

While developing his experimental work in Graz, Sechenov continued his studies on the physiologic bases of psychology, a subject which fascinated him from adolescent years.

Sechenov writes in his letter to his wife, dated February 18, 1867:

> "It is remarkable, darling, to what extent the saying 'As one is in the crib so he goes to the grave' finds, in my instance, complete justification. At one time, namely when I first went abroad, my old Moscow passion for philosophy seemed to me to be a fancy, a false note in life, and yet it now appears that I am going to occupy myself with a problem which enormously puzzled me during my student years—the absence of the subject of psychology in medical schools. I will tell you in secret that certain forms of psychologic experiments have already begun to move around in my head. They still are in a germinating form, but I think they will develop in time."

Sechenov studied German psychologic and philosophic literature very meticulously, and was utterly disappointed. On October 18, 1867, he writes to Maria Alexandrovna:

> "As I had ordered in the local bookstore all philosophical books available, I received a few days ago the newest

> literature which proved to be such a nonsensical mess that I did not understand one single word. And this still forms nowadays the subject of study of very many Germans. I must frankly confess to you, for the study of German metaphysics (about which I already talked to you), one would need more courage than I could ever master."

Sechenov continued to think about rebuilding the very foundations of a science which he considered to be one of the most important and fascinating branches of human knowledge—psychology. He hoped to be able to convince his scientific opponents, the subjective psychologists, and to demonstrate to them the enormous advantage presented by the study of psychologic phenomena with physiologic means. He conceived the idea of open discussions with representatives of the official psychologic science in order to bring out the truth. In his letter to his wife of November 4, 1867, Sechenov writes:

> "With regard to psychology there is now the following plan in my head. The principal representatives of Herbart's School live in Leipzig. I will have to be there in any event for a meeting with Ludwig. Therefore I have conceived the idea of approaching these gentlemen and telling them: 'You, as you say, wish that physiologists would also take part in the development of psychology. Well, I am a physiologist, and I have the same intention. So why not, during my stay in Leipzig, organize systematic debates on the basic problems of psychology?' Should this idea materialize it would be extremely useful."

Sechenov's proposal, needless to say, was disregarded.

SECHENOV'S RETURN TO ST. PETERSBURG. RENEWED ACTIVITY AT THE MEDICO-SURGICAL ACADEMY. FURTHER PERSONAL DISAPPOINTMENTS, AND RESIGNATION FROM THE ACADEMY. SECHENOV'S ACTIVITY AT THE UNIVERSITY OF ODESSA, AND HIS PHYSICOCHEMICAL AND PSYCHOBIOLOGIC STUDIES THERE. PUBLICATION OF THE ESSAY, "WHO SHOULD INVESTIGATE PSYCHOLOGICAL PROBLEMS, AND HOW." ITS PRINCIPAL THESIS AND CONCLUSION: PSYCHOLOGY IS A PHYSIOLOGIC DISCIPLINE. SECHENOV—PROFESSOR OF PHYSIOLOGY OF PETERSBURG UNIVERSITY. PUBLICATION OF THE PSYCHOPHYSIOLOGIC AND PHILOSOPHIC TREATISE, "ELEMENTS OF THOUGHT." THE CONCEPTS OF SPACE AND TIME AS A NEUROPHYSIOLOGIC PROBLEM. NEW DISAPPOINTMENTS. SECHENOV'S RESIGNATION FROM PETERSBURG UNIVERSITY. (1868–1888)

In the winter of 1868 Sechenov returned to St. Petersburg. He continued his work at the Medico-Surgical Academy, but things did not go well, and in 1870 Sechenov resigned. The immediate and overt reason for his resignation was again a deep personal disappointment.

Sechenov had proposed Ilya Mechnikov, later the famous pathologist and microbiologist, as a candidate for the vacant post of "Lecturer" in zoology. Mechnikov held at the time the Chair of Zoology at the University of Odessa and was already a scientist of international repute. The Academy rejected Mechnikov's candidacy and, the following day, Sechenov sent in his resignation.

The reason given by one of the members of the majority for rejecting the Mechnikov's candidacy is remarkable for the cynicism it displays. This member asserted that Mechnikov's scientific merits were great; indeed, so great that he fully deserved to be elected to any post, even that of a member of the Academy of Sciences. But, he added, this was precisely the reason which made his candidacy for the post of "Lecturer" at the Medico-Surgical Academy unacceptable. Up to then, this member argued, the Chair of Zoology at the Medico-Surgical Academy had been held by an assistant professor, since zoology is a subject of minor importance in the medical curriculum. If

Mechnikov were elected, a full professorship would have to be created for him, which could not be done.

Sechenov was very deeply pained by the attitude of the Academy. The letter which he wrote to Mechnikov after the ballot reflects this pain and indignation very vividly:

> "Believe me or not, but after this miserable comedy I was at one moment overtaken by such disgust and grief that I wept. It is good that I was able to cover my face with my hands in time, in order not to provide additional pleasure for the lackeys who surrounded me. Please forgive me for having been so mistaken about the moral qualities of my honorable colleagues, but at the same time you can see for yourself into what kind of a garbage dump you would have gotten if you had been elected."

Soon after Sechenov's resignation from the Medico-Surgical Academy the Council of Odessa University elected him to the Chair of Physiology of the Physico-Mathematical Faculty. After a year of waiting, and not without resistance from the higher authorities, Sechenov was finally nominated to the Chair by the Minister of Education. Together with his teaching program, he immediately organized a broad research program in his department. Scientific papers soon began to flow from his laboratory, among them one in collaboration with Mechnikov.

During his tenure in Odessa, Sechenov carried out a large number of absorptiometric investigations, which represented the second principal work of his life and which were continued at greater or lesser intervals for 25 years. The objective of these studies was to determine the state in which CO_2 is present in the blood, and the dynamics of its respiratory exchange. In a preliminary study, performed in **1872**, Sechenov carried out a series of experiments with salts, with the intention of applying the data thus acquired to the problem of absorption of the same gas by the various constituent parts of the blood. In **1875**, the work was completed and the results were published by the Academy of Sciences under the title, "Uber die Absorption der Kohlensäure durch Salzlösungen." This was followed by the publication, in **1879**, of the second part of Sechenov's absorptiometric studies, entitled "Die Kohlensäure des Blutes." "These two papers," as Sechenov himself says, "in spite of the considerable interval between their publications and in spite of the seeming difference of the subject-matter, are indivisible parts of one whole, both in idea and methods." The results of this work can now be found in any textbook of physiology. They showed that the red blood cells take part in the respiratory exchange of CO_2 by means of their hemoglobin and that the discharge of CO_2 from the blood into the air takes place according to the same laws as the diffusion, into the air, of gases dissolved in liquids.

In Odessa, Sechenov also wrote two important psychophysiologic essays in which he further developed his ideas and concepts expounded in "Reflexes of the Brain." One of these essays, entitled "Who Should Investigate the Problems of Psychology, and How," is of particular interest. Its fundamental tenets and conclusions are as follows.

Taking, as a point of departure, the notion extensively developed in his "Reflexes of the Brain," Sechenov stresses the fact that psychic experience, which he has shown to be associated with the middle link of the brain reflex, should not be confronted or compared with somatic events, and should not be studied independently of these events, as another category of phenomena. In order to demonstrate more didactically the unitary character of reflex acts on the one hand, and psychic phenomena on the other. Sechenov carries out first a comparison between reflexes and the more elementary forms of psychic experience, namely those manifested in the activity of the sense organs. He shows that the difference between the two groups of events is merely quantitative. "It follows," says Sechenov, "that the lower forms of psychic phenomena, which result from the activities of the sense organs, are allied in their nature to somatic nervous processes."

The only reason which still prevents many investigators from carrying out a truly scientific, objective study of psychic phenomena is, in Sechenov's opinion, the strong impression made on the minds of these investigators by the seeming "voluntariness" of human acts. But this is just an illusion, since all psychic events are subject to laws as immutable as the laws of material life. Even those acts which are clear expressions of "free will," and in which every step is taken consciously and deliberately by the acting person, cannot transgress definite limits. "Only the actions of a lunatic are often unaccountable; however, there can be no doubt that even in such cases there must be motives, although the relationship between these motives and the acts to which they lead may not be the same as in the normal person."

It should be noted in passing that, in the course of his analysis, Sechenov formulated a concept which, as is well known, is also the point of departure of Freud in his conception of "the unconscious." Sechenov emphasizes that *psyche* should not be identified with *consciousness*, that not all psychic phenomena are conscious, and that consequently conscious psychic processes represent only a portion of psychic life. "It is easy to show," says Sechenov, "the fallacy of the idea that psychic life begins and ends in our consciousness."

Who then should study psychologic problems? Sechenov answers this question unhesitatingly: Since the psychic event is just one phase, the middle link, of the complex reflect act, obviously it should be studied by those who investigate the act in its entirety, that is, by the physiologists.

"Nobody will doubt," says Sechenov, "that the study of psychology will henceforth fall into good hands, for modern physiology is characterized by its sound principles and good judgment. Being a science concerned with real facts, physiology will begin by separating psychologic reality from the mass of psychologic fiction which even now fills the human mind. . . . Psychology will gain enormously, for it will be based on scientifically verifiable facts instead of deceptive suggestions of the voice of our consciousness. Its generalizations and conclusions will be limited to actually existing analogies; they will not be subject to the influence of personal preferences of the investigator, which have so often led psychology to absurd transcendentalism, and they will thereby become really objective scientific hypotheses. The subjective, the arbitrary, and the fanciful will give way to a closer approach to truth. In brief, psychology will become a positive science. Only physiology can do all this, for only physiology holds the key to the scientific analysis of psychic phenomena."

When one considers that this was written almost a century ago, one can fully appreciate the significance of these pronouncements as well as the boldness, the enthusiasm and the deep scientific faith of their author.

In 1876 the Physico-Mathematical Faculty of Petersburg University elected Sechenov to the Chair of Physiology. With this appointment Sechenov obtained very satisfactory conditions for his scientific and teaching activities, and he made full use of them. Apart from continuing his physicochemical (absorptiometric) studies, he performed a number of physiologic experiments, investigating galvanic phenomena in the medulla oblongata of the frog, and developing further his studies on the inhibition of reflexes.

During the same period Sechenov published a study entitled "Elements of Thought." This work represents a further development of Sechenov's psychobiologic views and deals with the most fundamental concepts of philosophy. In this paper Sechenov poses the problem of the neurophysiologic nature of the concepts of *space* and *time*. He develops a daring and imaginative analysis of the role of the muscle as a sense organ which gives us the signals of position in space and of evaluation of time. Neither before nor after Sechenov has any physiologist dared to approach this problem.

In the middle of the eighties an attempt was again made to elect Sechenov to the Academy of Sciences, and he was duly elected in the corresponding section of that institution by a vast majority of votes. Nonetheless, the Minister of Interior and the President of the Academy, Count Dimitry Tolstoy vetoed the second and decisive vote in the General Assembly of the Academy.

In 1886 another disappointment awaited Sechenov. The Minister of Education, Delanov, declined the petition of Petersburg University to grant Sechenov the rank of Professor Emeritus, although he was formally entitled to this rank, having occupied the post of professor for more than 25 years.

Discouraged and disgusted, Sechenov decided to give up his professorship in St. Petersburg for the more modest post of "Lecturer" at Moscow University. He resigned from Petersburg University in 1888 and, after a year's rest in the country, he returned to his Alma Mater, to remain there for the rest of his life.

SECHENOV IN MOSCOW. HIS PROFESSORSHIP AT THE UNIVERSITY. LAST YEARS OF RESEARCH AND TEACHING. EXPERIMENTS ON THE PHYSIOLOGY OF PHYSICAL WORK. SECHENOV'S FINAL DISAPPOINTMENT—REMOTE ECHO OF THE TURBULENT "REFLEXES OF THE BRAIN." DEATH OF THE "FATHER OF RUSSIAN PHYSIOLOGY." (1889–1905)

When Sechenov joined the staff of Moscow University in 1889 the Chair of Physiology was held by Professor F. B. Sheremitievsky. Sechenov offered a course in physiology as "Private Lecturer." At the same time he delivered a systematic course of lectures on the physiology of the central nervous system to medical practitioners at the so-called Doctors' Club.[10]

Sechenov's financial position at the time was very precarious. When his teacher, Ludwig, learned of this he immediately suggested that Sechenov come to work with him. Recalling these difficult days in his *Autobiographical Notes* Sechenov writes: "My position at that time was so insecure that Ludwig, without any hint on my part, told me that as long as he was alive there would always be a place for me in his laboratory."

However, in the fall of 1891 Sechenov, then living on the small estate of his wife, received a telegram from the Curator of Moscow University informing him of the sudden death of Professor Sheremetievsky and offering him the vacant Chair of Physiology. Commenting on this offer, Sechenov writes, "Knowing that I would be more useful in this capacity than as a Lecturer without even a place to work, I felt it was my duty to accept. During the subsequent ten years I had no reason to regret my decision."

Professor Shaternikov, one of Sechenov's students and later his successor to the Chair of Physiology, describes very vividly with what impatience Sechenov's first lecture was awaited by the medical students, and what a deep impression it created. "The hall was crowded with students of the Medical and Physico-Mathematical Faculties; the seats were all occupied; the gangways, even those leading to the platform, were crammed. The tension increased every minute and, when at last the door opened and Sechenov came in, making his way to the front, the pent-up feelings broke out in a storm of applause.

"Sechenov was evidently moved by the

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[10] These lectures were later published in book form under the title, *Physiology of the Nervous Centers*.

students' reception. Without raising his head, in a faltering voice, he began, 'With deep gratitude I have accepted the high honor which my Alma Mater, Moscow University, has conferred upon me by electing me to the Chair of my esteemed late colleague, F. B. Sheremetievsky.' After this, he turned to the importance of physiology, as a science, and to the classification of the subject-matter. His voice became stronger, resuming its usual ringing notes; the phrases came flowing in a harmonious stream; his eyes gleamed with enthusiasm. Once again he was leading a young generation forward."

Sechenov wrote to Ludwig to inform him that he had accepted the Chair of Physiology. Ludwig replied, in part:

> "When, a month ago, I read in the Viennese press the announcement of the death of Sheremetievsky, I was worried about your future. It seemed to me possible that they would push forward somebody else, less suitable. Your letter freed me from this apprehension.... How great my joy was cannot be expressed with the pen. Enough, you are again where we wish to see you. Since you will meet very distinguished colleagues in Moscow and will live and teach in the heart of your beloved people, a new era will open before you, richer and happier than all the previous ones."

During these late years of his life, Sechenov was just as brilliant as an investigator and just as successful and beloved as a teacher, as he had ever been before. In every step and action there was the same striking feature of his character—the perfect honesty and profound hatred for any form of hypocrisy, even the most innocent and generally accepted one. Professor Shaternikov, recalls the following episode:

In the spring of 1895 a deputation from the University professorate approached Sechenov to inform him of the intention of Moscow scientists to celebrate the 35th anniversary of his professorship. When asked to fix the date of the celebration, Sechenov categorically refused. After much argument one member of the delegation, the well-known plant physiologist Timiriazev, pointed out that Sechenov had no right to refuse, since this celebration was a matter of social importance and could not be approached from any personal angle. Sechenov replied that he could not prevent them from celebrating anything they wanted, but he warned them that if such a celebration did take place he would be out of town on that day.

After the departure of the delegation Shaternikov asked his teacher to explain his attitude. Sechenov replied, "My dear fellow, such ceremonies always lead to exaggerations and extravagances. Besides, there is bound to be some talkative gentleman who will say something that will make me wish to sink through the earth. No, thank you, I do not want to have people make a fool of me before a gaping crowd."

Soon after his arrival in Moscow, Sechenov was asked to deliver a course of lectures at the "Women's Pedagogic Society." This was an institution formed in Moscow after the so-called Bestuszev Courses in St. Petersburg had been closed by the Government. The Society obtained permission to organize "collective lessons" for women teachers with the objective of improving their professional qualifications. Sechenov accepted this invitation joyfully.

"I will always remember with deep satisfaction my lectures at the Courses of the Women's Pedagogic Society," writes Sechenov in his *Autobiographical Notes*. Here, just as in the pleasant circle of my Bestuszev students, reigned that atmosphere of freedom coupled with straightforwardness, friendship and mutual esteem, which one encounters in families with a high level of culture and which is a proof of the honesty of aims and the mutual devotion of young and old."

During this period Sechenov also deliv-

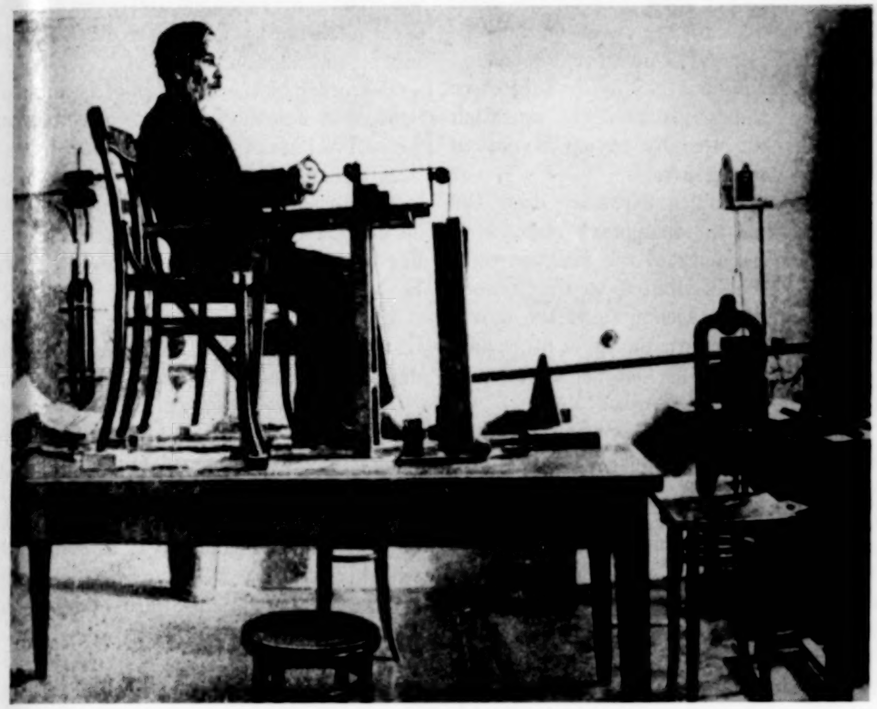

FIG. 2. I. M. Sechenov carrying out on himself one of his last experiments (1902). Reproduced from I. M. Sechenov, *Autobiographical Notes*. Edition of the Academy of Sciences of U. S. S. R., 1945.

ered a series of public lectures, usually for the purpose of collecting funds for educational institutions and destitute students.

In 1899, wishing to "give younger men a chance," Sechenov gave up both the obligatory course at the University and his lectures at the Courses for women teachers. In 1901 Sechenov formally resigned his professorship, though he continued to work in the laboratory and performed a series of ingenious experiments on the physiology of muscular activity. His findings were later published (in German) under the title, "Contribution to the Problem of the Effect of Sensory Stimuli upon the Muscular Work of Man." In those investigations Sechenov used himself as the experimental subject. He first performed rhythmic work with the right arm until fatigue set in. Then followed a period of rest for five minutes. After the rest, the right arm again carried out work until fatigue, and again a period of five minutes' rest followed, but this time the *left* arm carried out work during this period. Sechenov found that the working capacity of the right arm proved greater in the second case than in the first one (when the left arm did not work).

He then undertook to ascertain whether movements in other parts of the body had the same recovering effect upon the fatigued right arm. He chose for the new experiment movements of the legs, and was able to demonstrate that the working capacity of the fatigued right arm was also increased by the work of the legs. The same effect appeared to apply to *any strong movement* of the body. He further found in these experiments that there was no difference in the recovering effect whether the region selected for producing this effect was on the same side as the working organ, or on the opposite side. It should be noted that Sechenov judged the results not only by the subjective criterion of the intensity of the sensation of fatigue, but also by myograms taken from the working arm.

From these studies Sechenov drew the conclusion that the temporary increase in the working capacity of the fatigued right arm had to be attributed to the sensory impressions which accompanied the movements of the other arm, or leg, or other part of the body; in other words, to sensory stimulations of the nervous system.

From the point of view of present-day cerebral physiology Sechenov's interpretation of his findings is not entirely acceptable. Yet his ingenuity in conceiving and executing these experiments under most primitive laboratory conditions demonstrated once more the remarkably active mind of the 73-year-old scientist.

During this period Sechenov also labored on the preparation of a new edition of his psycho-physiologic and philosophic essay "Elements of Thought." The final revision appeared in 1903, two years before Sechenov's death.

In the fall of 1903, Sechenov, now 74, was again at work in the cause of education. In this instance he was concerned with an evening course of lessons in anatomy and physiology, designed for factory workers, which he conducted at the so-called" Prechistensky Classes". The lectures were accompanied by demonstration experiments performed by Professor Shaternikov. Sechenov was extremely gratified with the deep interest shown and the progress made by his students. From October 1903 to February 1904, he completed his lectures on the structure and movements of the skeleton, on the physiology of the integuments, on digestion, respiration, and circulation. What remained was the part of the course closest to Sechenov's heart, the physiology of the nervous system. Then the blow came. About the middle of February 1904, the Head of the Prechistensky Classes received the following notification.

"By order of the Director of Elementary Schools of February 5, 1904, No. 814, Professor Ivan Mikhailovich Sechenov has not been confirmed in the post of teacher of the Prechistensky Classes, and therefore I will be obliged for your informing me that he has been relieved of his duties. Chairman, K. Mazing."

The aged Sechenov, only a year before his death, was still remembered as the dangerous author of "Reflexes of the Brain."

The last two years of his life Sechenov spent completing his autobiography. He also planned new experiments, but death put an end to his plans. In the fall of 1905 he contracted pneumonia and died in Moscow on the second of November. In compliance with his will no flowers were brought to the funeral and no speeches were made over his grave.

So ended the life and activity of I. M. Sechenov, one of the most brilliant physiologists of the nineteenth century.

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ELECTROENCEPHALOGRAPHIC FINDINGS DURING CHLORPROMAZINE-DIETHAZINE TREATMENT[1]

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The correlation of specific brain wave changes with the various psychiatric diagnostic groupings is still a matter of speculation. Strauss *et al.* (15) believe that "there is no electroencephalographic pattern specific for schizophrenia or the affective psychoses." Greenblatt (6) noted large amounts of fast activity in the involutional psychoses and the manic-depressive, depressed disorders. Kammerer *et al.* (9), as part of a general investigation of the electroencephalogram in psychiatric disorders, found only 21 normal electroencephalograms in 80 patients with the diagnosis of melancholia. Dysrhythmia, slow waves and bursts, as well as fast rhythms, were the predominant abnormalities. Dongier (3) in his review of the problem concluded that the "diagnostic and prognostic significance of the various functional modifications" of the electroencephalogram was far from settled and that further work was necessary along those lines.

Clinical observations of depressed patients during chlorpromazine-diethazine treatment suggested the need for parallel laboratory studies (1). It was felt that the electroencephalogram might give some clue regarding the moderate to severe extrapyramidal syndrome that developed. Examination of 1044 routine electroencephalograms at this hospital from September, 1953 to January, 1957, showed slow wave bursts to be a frequent finding in depressed patients, particularly in the involutional period. Serial electroencephalographic studies of a small sample of this group could yield information not obtainable by a mass survey or by doing only one record at the beginning and end of treatment.

MATERIALS AND METHODS

Six female and four male patients, ranging in age from 30 to 60 years, were studied (Table 1). Their diagnoses were varied and only one was a catatonic schizophrenic. Electroencephalograms were recorded with an eight channel Medcraft machine utilizing 17 electrode placements according to Strauss' method (15). A control record was done for each patient before medication was begun. Electroencephalograms were repeated every 7 to 10 days thereafter; 100 mg. of chlorpromazine, and from 250 to 500 mg. of diethazine were given three times daily. Regular notes were made by a special treatment nurse assigned to the psychopharmacologic studies. Sixty electroencephalograms were done in eight patients (whose records became abnormal during treatment), and six in the other two patients. Eight patients were treated from 31 to 56 days and two from 68 to 70 days.

RESULTS

Before Treatment. Five of the control records were normal and five abnormal. Disorganization of the alpha rhythm, often accentuated during hyperventilation, symmetrical slow wave activity (5 to 6 c.p.s.), slow wave bursts, and irregular low voltage fast waves were seen in the latter records. One patient had poorly organized low voltage 19 to 23 c.p.s. activity as the dominant rhythm, with scattered alpha waves. In another patient (I. G.) photic stimulation at 10 and 15 flashes per second produced high voltage spike and slow wave discharges

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[1] Read before the Annual Meeting of the Society of Biological Psychiatry, Atlantic City, June, 1957.

[2] Manhattan State Hospital, Ward's Island, New York, and College of Physicians and Surgeons, Columbia Univesity, New York.

TABLE 1

Serial Electroencephalographic Results of 10 Depressed Psychotic Patients after Chlorpromazine and Diethazine Therapy

Case No.	Patient	Age	Sex	Diagnosis*	Electroencephalogram†			Duration Treatment	EEG Abnormality Duration
					Control	During	After		
								days	*days*
1	A.M.	59	M	IPM	N	N	N	44	0
2	W.F.	33	M	DPP	N	N	N	52	0
3	P.C.	40	F	DPP	N	A	N	68	42
4	P.L.	30	F	DPP	N	A	A‡	31	24
5	M.G.	53	F	MDD	A	A	N	37	7
6	I.G.	37	F	DPM	A	A	N	56	48
7	J.C.	34	M	DPP	N	A	N	52	34
8	M.P.	43	F	IPM	A	A	N	46	38
9	L.B.	60	F	MDD	A	A	A	70	70
10	J.P.	38	M	DPC	A	A	N	46	17

* IPM, involutional psychosis, melancholia; DPP, dementia praecox, paranoid; DPM, dementia praecox, mixed; DPC, dementia praecox, catatonic; MDD, manic-depressive, depressed.

† N, normal; A, abnormal.

‡ Placed on electroconvulsive treatment.

during the period of stimulation accompanied by generalized twitching movements and followed by a period of confusion.

During Treatment. The abnormality became more pronounced in the five patients whose electroencephalograms were already abnormal. The alpha was more disorganized with an irregular distribution of the various frequencies. Delta amplitude and per cent time increased as well as the amplitude and number of bursts. The seizure discharge in patient I. G. became particularly pronounced. The abnormality was especially prominent in the symmetrical temporal regions in three patients, and in the symmetrical occipital areas in one patient.

Three of the five normal records became abnormal during treatment (Figs. 1, 2, 3). This took place 7, 11 and 13 days, respectively, after treatment began. The control

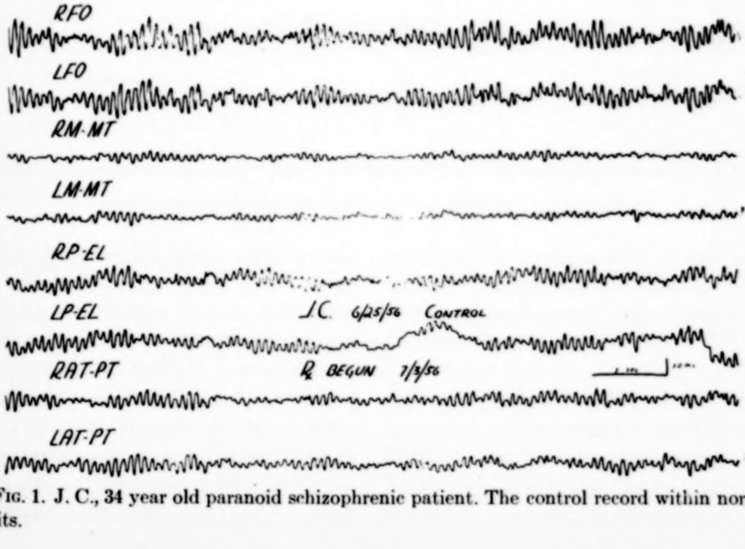

FIG. 1. J. C., 34 year old paranoid schizophrenic patient. The control record within normal limits.

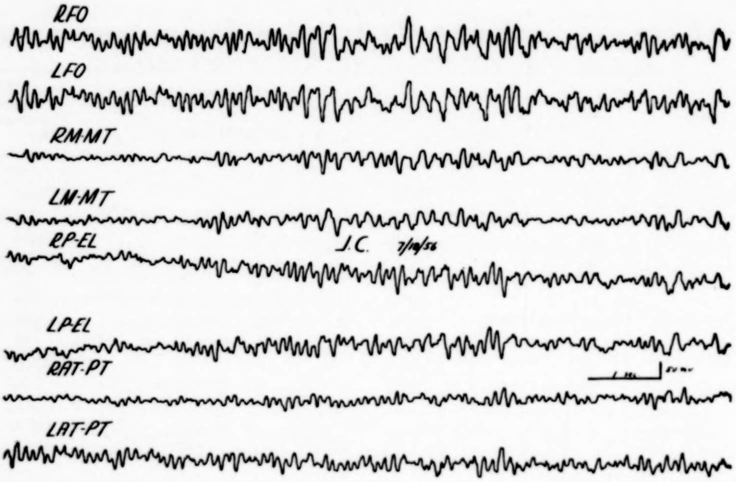
RFO
LFO
RM-MT
LM-MT
RP-EL
J.C. 7/18/56
LP-EL
RAT-PT
LAT-PT

FIG. 2. J. C., Fifteen days after treatment began; well defined slow wave burst activity present.

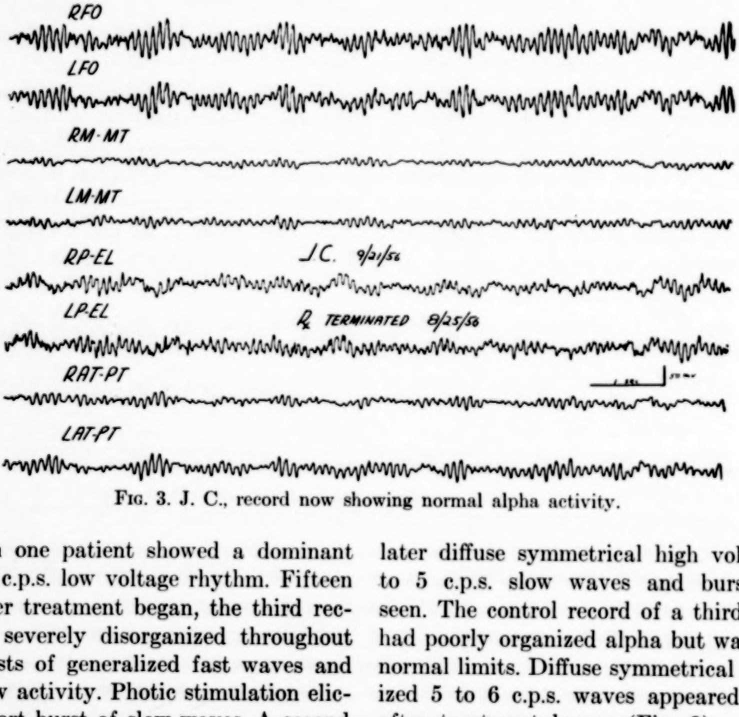
RFO
LFO
RM-MT
LM-MT
RP-EL
J.C. 9/21/56
LP-EL
℞ TERMINATED 8/25/56
RAT-PT
LAT-PT

FIG. 3. J. C., record now showing normal alpha activity.

record in one patient showed a dominant 16 to 35 c.p.s. low voltage rhythm. Fifteen days after treatment began, the third record was severely disorganized throughout with bursts of generalized fast waves and some slow activity. Photic stimulation elicited a short burst of slow waves. A second patient's record showed one well defined 5 c.p.s. high voltage generalized burst 11 days after treatment began, and one week later diffuse symmetrical high voltage 4.5 to 5 c.p.s. slow waves and bursts were seen. The control record of a third patient had poorly organized alpha but was within normal limits. Diffuse symmetrical generalized 5 to 6 c.p.s. waves appeared 7 days after treatment began (Fig. 2).

There were some minor variations in the amplitude in most patients during treatment. The amplitude was markedly in-

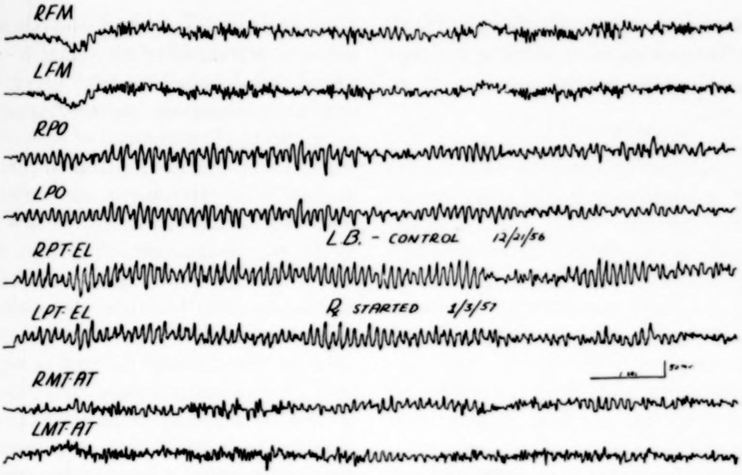
RFM
LFM
RPO
LPO
RPT-EL
L.B. - CONTROL 12/21/56
LPT-EL
℞ STARTED 1/3/57
RMT-AT
LMT-AT

FIG. 4. L. B., 60 year old manic-depressive, depressed patient. The control record shows slow wave bursts with occipital predominance.

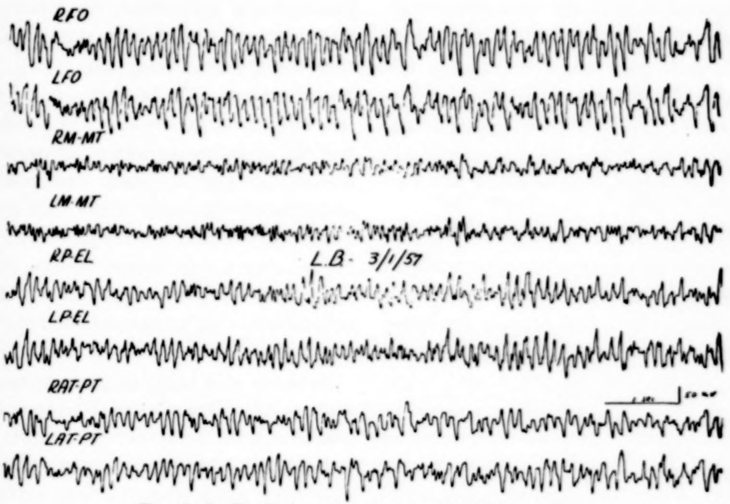
RFO
LFO
RM-MT
LM-MT
RP-EL
L.B - 3/1/57
LP-EL
RAT-PT
LAT-PT

FIG. 5. L. B., high voltage generalized slow waves.

creased in patient L. B. (Figs. 4, 5). Treatment accentuated the already existing electroencephalographic abnormality and induced abnormal changes in three of five patients. Two records were unchanged.

After treatment. Two records were still unchanged. One patient was discontinued from treatment after 31 days and placed on electroconvulsive therapy. Her record at that time was still abnormal. One patient continued to show symmetrical high voltage 5 c.p.s. burst activity with occipital predominance after 70 days of treatment (Fig. 5). This was still present to some degree 80 days after treatment had stopped. The seizure discharge induced in patient I. G. before and during treatment was no longer present. The other six records were normal. Organization of the brain wave activity improved. Slow waves were only scattered or absent. Fast activity had diminished. The fast frequencies were slowing and approaching the alpha range.

DISCUSSION

Is there a specific cerebral electric abnormality in depression? The data cannot answer this question until a much larger group of patients has been studied, although the initial findings of 5 abnormal records in 10 suggest this possibility. While the diagnosis of each record may be questioned, the most frequent abnormality was represented by delta and burst activity. Our observations in this hospital indicate that a low voltage, poorly organized fast record with varying frequencies is abnormal, although this view is disputed (15). It cannot be implied that the slow wave electroencephalograms were of the type frequently seen in catatonic schizophrenia (7), since there was only one such patient in the group. The electroencephalographic abnormalties were present for most of the treatment period and, with one exception (L. B.), disappeared before treatment was terminated.

Morrice (12) has reviewed the question of slow wave production in the electroencephalogram in relation to carbon dioxide and feels that the delta waves produced by this gas are diencephalic in origin. The slow rhythms in the epileptic and post-electroshock electroencephalogram are suppressed by mescaline and we have already suggested a diencephalic mediation of this drug's effect. Roth has expressed the belief that the effects of electroconvulsive therapy are on the diencephalic structures. Since chlorpromazine-diethazine induced or augmented slow waves and bursts as well as seizure discharges after photic stimulation, it would not be unreasonable to suggest that the diencephalon is one pathway through which the effects of these agents are mediated. Clinically it is not possible to elaborate this hypothesis further.

The increased abnormality during treatment in Cases 5, 6, 8, 9 and 10 and drug induced abnormality in cases 3, 4 and 7 would certainly indicate the involvement of central mechanisms in mediation of the drug effects. The absence of spike and slow wave discharges in response to photic stimulation after treatment in patient I. G. would support this concept. This is contrary to the psychoanalytic hypotheses that hold for a purely psychogenic mechanism in explaining results with chemotherapy in psychiatry (13).

Is the abnormality induced or aggravated by either chlorpromazine or diethazine, or is this a synergistic action? In general, long term administration of chlorpromazine usually produced a more stable record (10). Chlorpromazine alone increased the amplitude and alpha per cent time (16). Single intravenous injections of chlorpromazine were without immediate specific effects on the electroencephalogram (14). Mauceri and Strauss (11) stated that "chlorpromazine in large doses can produce in a patient without epilepsy or organic brain disease a type of electroencephalographic abnormality usually found in epileptics." Doussinet *et al.* (4) reported that electroencephalographic abnormalities (high voltage slow waves) were observed during chlorpromazine treatment in psychotic patients.

Jenkner and Lechner (8) administered intravenous diethazine to 10 normal patients and noted a moderate reduction of alpha activity. In patients with pathologic records following head trauma, slow wave activity was frequently abolished. Alpha activity was diminished in varying degrees. Fink (5) found that intravenous diethazine reduced slow wave activity following electroconvulsive treatment.

A control group of five non-depressed psychotic patients receiving chlorpromazine for 6 weeks showed fast activity in one patient, no change in the electroencephalograms or increased synchrony with improvement of alpha activity in the others.

The effects of diethazine alone could not be studied. It is possible that the electroencephalographic findings reported herein result primarily from the action of chlorpromazine and secondarily from the synergistic effects of both drugs. It is paradoxical that chlorpromazine can induce slow wave activity and diethazine abolishes these wave forms. Yet both together induce or increase existing delta activity. This would be similar to their clinical action. Chlorpromazine alone produces extrapyramidal reactions in about 7 per cent of patients (2). Diethazine is an anti-Parkinson agent. Yet the combination induced a moderate to severe extrapyramidal reaction in most patients treated.

There is no apparent explanation for the conversion of four abnormal records before treatment to normal tracings after treatment (Table 1). The smallness of the sample likewise did not allow for correlation of the clinical condition with electroencephalographic changes.

The review of serial records suggests that any single record which is markedly disorganized, with few slow waves, or dominated by irregular low voltage fast wave activity should be repeated one or several times. Such records are probably abnormal. While the question of specificity of electroencephalographic patterns for the various psychiatric groups is difficult to establish, this work would seem to indicate that a basic electrophysiologic instability may exist in the depressed patient.

SUMMARY AND CONCLUSIONS

1. Six female and four male patients with psychotic depressions were treated with chlorpromazine and diethazine. Serial electroencephalograms were done.
2. Five records were normal and five abnormal before treatment. Eight were abnormal during treatment. Only one remained abnormal after treatment.
3. These drugs probably act via subcortical centers, possibly diencephalic.
4. It is postulated that a cerebral electrophysiologic instability may exist in psychotic depressions.

Acknowledgments. Miss Dorothy Kauffman, R.N., gave much assistance during this study. Chlorpromazine and diethazine (SKF 1026A) were supplied through the courtesy of Mr. William E. Kirsch, Research Associate, Smith, Kline & French Laboratories, Philadelphia.

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BRIEF COMMUNICATION

PULMONARY EDEMA
AN UNUSUAL COMPLICATION ASSOCIATED WITH TRANQUILIZER THERAPY

M. H. SHEARD, M.R.C.P.[1]

The respiratory complications of tranquilizing medication are not common, although Wardell (6) and Feldman (2) have reported deaths suggestive of a diminution in air passageway defenses. Laryngeal and peripheral edema have been reported. The following case is of interest as an unusual respiratory complication of chlorpromazine and because of its possible significance in the etiology of pulmonary edema.

CASE REPORT

A 53-year-old white male was admitted to Danvers State Hospital in May of 1939 with delusions, hallucinations, and disturbed behavior. A diagnosis of paranoid schizophrenia was made. Admission examination and subsequent annual physical examinations revealed no significant physical abnormalities. Treatment with Thorazine was begun in December of 1956, with dosage increasing to 200 mg. q.i.d. by April, 1957. The annual physical examination in March of 1957 revealed no abnormal cardiac or pulmonary findings.

On the third of May the patient began to experience great respiratory difficulty. He became cyanotic and began coughing up large quantities of frothy mucoid sputum. Examination revealed diffuse moist bubbling rales. At this time the patient spoke of two or three similar unreported attacks, of a minor nature, during the previous week. Under treatment he first improved but then became febrile and his condition deteriorated. Chest x-rays revealed increasing patchy basal consolidation; EKG. was normal. The patient died on the tenth of May; post-mortem findings revealed bronchopneumonia; the heart was normal.

DISCUSSION

The diagnosis of pulmonary edema was made on the basis of large quantities of frothy mucoid sputum and diffuse moist bubbling rales. It is relatively rare to find pulmonary edema in the absence of cardiac pathology. It is felt that the most likely explanation for this edema was a disturbance in the pulmonary capillaries brought about by impairment of the nervous vasomotor control operating either centrally or peripherally and induced by the parasympatholytic and adrenolytic properties of the chlorpromazine. This would lend support to the neurogenic theory of pulmonary edema based on the experiments of Farber (1), Luisada (4), and Jarisch (3). This neurogenic theory is the most likely explanation for cases of pulmonary edema occurring after brain lesions or in insulin shock treatment (Schlesinger (5)). It is also interesting that acetone was found in this patient's urine and has been reported also in brain lesions.

SUMMARY

1. A case of pulmonary edema on chlorpromazine is reported.

2. It is suggested that the etiology could be a disturbance in the vasomotor control of the pulmonary capillaries.

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BRIEF COMMUNICATION

A HYPNOANALYTIC NOTE ON THE HEART AS A PHALLIC SYMBOL

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It has long been known that many parts of the body may be invested with phallic significance. The heart as a phallic symbol was recently depicted so precisely and specifically that it merits addition to a well documented literature on cardiac neuroses (1, 2). The manner in which the identification was ascertained during a hypnoanalysis is of therapeutic interest.

The patient, thirty-three years old, was an overt, active homosexual, anxious and depressed, seeking help in connection with sensitivity and insecurity in interpersonal relations. He had had a nocturnal dream which he was retrieving soon afterwards during a hypnoanalytic session. Prior to dreaming he had been discussing with acquaintances the stimulating effect of a vibratory apparatus for scalp massage. Sexual excitation was the point of interest. As he recaptured hypnotically the frightening and previously unrecalled dream, the vibrator was being used on him. At first his close friend was manipulating it. Then the friend changed into his mother. She applied the vibrator to his chest. He relived the dream intensely with its sensorimotor accompaniments as he writhed uncomfortably, groaned, and complained of pain. He immediately associated penis with heart. He based this on his conception of a heart's anatomical appearance as he recalled it from childhood when fowl were eviscerated by his mother during household chores.

The patient had previously mentioned the frequently encountered childhood recollections of threats by mother to have his penis cut off if he continued to manipulate it. The discomfort in his dream relating to the symbolic representation of this threat was quite consistent with his severe and consciously experienced castration anxiety. In childhood the castrating mother was to call on the family doctor for this purpose. The friend in the dream who was his neighbor in fact, assumed this role in essence during their every day relationship. Soon after the dream interview the patient expressed fear that his homosexuality would be stripped from him as a result of the analytic process.

His inner turmoil was further illustrated by many dreams of animals eviscerated and mutilated, of physical damage to himself, and of women mutilated by him. His hostility toward women was admittedly great. He had also become keenly aware of his deep feelings of self-depreciation and crippling masochism. Other aspects of his personality will not be elaborated because they occur frequently in this type of patient and are well known.

The patient had always been concerned about his heart and had always worried that it might be organically damaged. He was acutely aware of sensations in his chest which he tended to ascribe to cardiac malfunctioning. He had supplied this information prior to his dream but did not stress or allude to it often. Following revivification of the dream he made no reference to it for several weeks. When mentioned again as a tangential issue he said he experienced no longer the previously described concern about his heart. Although anxiety of this kind might not ordinarily be expected to disappear so rapidly, it is not so surprising in this case because of the large reservoir of castration fear that was potentially and readily capable of being

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